2020-12

MEASURING RESILIENCE

Boyle, Joshua L.

Monterey, CA; Naval Postgraduate School

http://hdl.handle.net/10945/66593

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

MEASURING RESILIENCE

by

Joshua L. Boyle

December 2020

Thesis Advisor:	Nita L. Shattuck
Co-Advisor:	Bradley J. Strawser
Second Reader:	Panagiotis Matsangas

Approved for public release. Distribution is unlimited.

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington, DC 20503.			
1. AGENCY USE ONLY ***(Leave blank)***	**2. REPORT DATE** December 2020	**3. REPORT TYPE AND DATES COVERED** Master's thesis	
4. TITLE AND SUBTITLE MEASURING RESILIENCE			**5. FUNDING NUMBERS**
6. AUTHOR(S) Joshua L. Boyle			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release. Distribution is unlimited.			**12b. DISTRIBUTION CODE** A

13. ABSTRACT (maximum 200 words)

After nearly two decades of war in the Middle East and centuries of conflict, today's service member is more vulnerable then ever. Our nation's warriors can deploy to and redeploy from combat in a matter of hours, not the days, weeks, or months of the past. The growing, enduring, and repeating stressors of military service have placed a premium on creating resilient Soldiers, Sailors, Airmen, and Marines. Yet, currently, there is still a void of knowledge surrounding how best to tangibly assess or train the resilience of service members and how to proactively identify those who are at risk or headed towards risk of compromising their resilience. The aim of the current study is to associate physiological metrics with self-reported assessments to enable such a proactive approach to occur. The study occurred outside the sterile confines of the laboratory, choosing instead to follow 44 service members in their normal patterns of life. In collaboration with the University of Arizona, participants in the present study were asked to wear a commercially available health tracker, an ŌURA ring, while self-administering proven subjective assessments and "awareness training," on an online platform. The results found statistically relevant associations between heart rate variability metrics and the subjective assessments of anxiety, depression, and compassion fatigue. Further studies are needed to confirm and explore these associations, as well as further analysis of the plethora of data.

14. SUBJECT TERMS resilience, emotional intelligence, emotional intelligence training, wearable, Oura ring, heart rate variability, psychophysiological			**15. NUMBER OF PAGES** 127
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UU

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

THIS PAGE INTENTIONALLY LEFT BLANK

MEASURING RESILIENCE

Joshua L. Boyle
Major, United States Army
BS, U.S. Military Academy, 2009

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN DEFENSE ANALYSIS
(IRREGULAR WARFARE)

from the

NAVAL POSTGRADUATE SCHOOL
December 2020

Approved by: Nita L. Shattuck
Advisor

Bradley J. Strawser
Co-Advisor

Panagiotis Matsangas
Second Reader

Douglas A. Borer
Chair, Department of Defense Analysis

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

After nearly two decades of war in the Middle East and centuries of conflict, today's service member is more vulnerable than ever. Our nation's warriors can deploy to and redeploy from combat in a matter of hours, not the days, weeks, or months of the past. The growing, enduring, and repeating stressors of military service have placed a premium on creating resilient Soldiers, Sailors, Airmen, and Marines. Yet, currently, there is still a void of knowledge surrounding how best to tangibly assess or train the resilience of service members and how to proactively identify those who are at risk or headed toward risk of compromising their resilience. The aim of the current study is to associate physiological metrics with self-reported assessments to enable such a proactive approach to occur. The study occurred outside the sterile confines of the laboratory, choosing instead to follow 44 service members in their normal patterns of life. In collaboration with the University of Arizona, participants in the present study were asked to wear a commercially available health tracker, an ŌURA ring, while self-administering proven subjective assessments and "awareness training," on an online platform. The results found statistically relevant associations between heart rate variability metrics and the subjective assessments of anxiety, depression, and compassion fatigue. Further studies are needed to confirm and explore these associations, as well as further analysis of the plethora of data.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF FIGURES

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

AUDIT	Alcohol Use Disorders Identification Test
BDI-II	Beck Depression Inventory-II
BPAQ	Buss-Perry Aggression Scale
CD-RISC	Connor-Davidson Resilience Scale
COVID-19	severe acute respiratory syndrome-2, novel coronavirus 2019
CVC	cardiac vagal control
DERS	Difficulties in Emotion Regulation Scale
EI	emotional intelligence
EIT	Emotional Intelligence Training
HRV	heart rate variability
HR	heart rate
IBI	inter-beat-interval
IGT	Iowa Gambling Task
IIP-32	Inventory of Interpersonal Problems
IRB	Institutional Review Board
MBI-GS	Maslach Burnout Inventory—General Survey
MSCEIT	Mayer-Salovey-Caruso Emotional Intelligence Test
MSPSS	Multidimensional Scale of Perceived Social Support
NPS	Naval Postgraduate School
PANAS	Positive and Negative Affective Schedule
PCL-5	Posttraumatic Stress Disorder Checklist for DSM-5
PAI	Personality Assessment Inventory
PPG	photoplethysmography
ProQOL	Professional Quality of Life Scale
PSQ	Patient Stress Questionnaire
PSS-10	Perceived Stress Scale
PWB	Psychological Well-Being Scale
SCAN	Social, Cognitive, and Affective Neuroscience
SREIS	Self-Rated Emotional Intelligence Scale
STAI	State-Trait Anxiety Inventory
SWLS	Satisfaction with Life Scale

THIS PAGE INTENTIONALLY LEFT BLANK

ACKNOWLEDGMENTS

First, I would like to express my sincere and genuine thanks to Dr. Nita Shattuck and Dr. Panagiotis Matsangas for their unwavering support. From the beginning, the two of you believed in my project, my pursuit, and my reasoning. You took a rough-shod piece of clay and carefully molded it into a final product that demonstrates the applicability and feasibility of an individualized and proactive approach to holistic health. Without your brilliant minds, resolute patience, and magnificent teaching abilities, this project would have failed. Words cannot express the gratitude I feel or replace the countless hours I have stolen from you to pursue this study.

To Dr. Strawser, thank you for your staunch support of me, my educational ambitions, and my goals that fell outside of the scope of this project. Your Socratic approach is not lost on me; you are indeed a sage.

Thank you to all of our participants. Your patience and understanding made this thesis possible. My apologies that parts of the study were not as advertised. I hope each of you still learned something about yourself and has become better through this exploration: Praestantia per Scientiam.

Lastly, and most importantly, thank you to my wife. In these last eighteen months, you have been a true inspiration and an indomitable source of strength for our family. Through two train-ups, the lockdown, the fires, a month of parenting alone, and a twelve-month scramble to get a study approved, conducted, and written, you have been a model of resilience. Without your resolute support, none of this would have been possible. You are the true strength of our family and a truly remarkable role-model for us all. Thank you.

THIS PAGE INTENTIONALLY LEFT BLANK

I. INTRODUCTION

There is nothing bad in undergoing change—or good in emerging from it.

—Marcus Aurelius, *Meditations* 4.42
(Aurelius, 1984, p. 46)

A. SCENE SETTER

As the briefing concluded and all eyes returned to the head of the table, the commander took a breath, looked around the room deliberately, and asked, "*How do I train resiliency*?" Two years ago, I found myself sitting against the wall of a small conference room listening to a discussion between the unit commander and his personal staff. The topic was somber and fundamentally critical. It had been a tough year for the unit; there were several combat casualties, training casualties, and to the topic at hand: suicides. The gathering was comprised of the unit surgeon and medical team, the psychologist and the behavioral health team, the chaplain team, the family advocacy team, and the command team. The staff had just completed their brief on the current trend in suicides, the measures that subordinate units were taking to care for their members, and initiatives they were spearheading to hinder a growing concern–all of which centered around the term *resilience*.

Resilience has applicability across various fields ranging from engineering to ecology to business and culture (Coutu, 2002; Folke et al., 2010; Meredith et al., 2011, p. 2). This thesis's focus is resilience as it applies to humans, which, as a concept, is now approaching 70 years of research. Norman Garmezy first conceptualized *resilience* when he identified it in children of schizophrenic parents who grew up without psychological suffering (Coutu, 2002; Richardson, 2002). More precisely, this thesis focuses on the United States Military Service members and the unique challenges in the construct of *stress* and *resilience*. A plethora of definitions exist for *resilience*; most employ the concept of growth and adaptability while exposed to some form of opportunity, risk, adversity, misfortune, change, or stress (Connor & Davidson, 2003; Folke et al., 2010; Meredith et al., 2011; Richardson, 2002; Silverman & Deuster, 2014; Ungar, 2006; Wu et al., 2013). The application of this definition and its various components has led to resiliency, within an individual, being discussed as three main pillars: biological (physiological), psychological, and spiritual (Connor & Davidson, 2003; Richardson, 2002). Within these pillars, there is a whole manner of contributing factors, characteristics, or qualities for each (Connor & Davidson, 2003; Meredith et al., 2011; Richardson, 2002; Wu et al., 2013). As they will be referred to throughout this thesis, these factors are both quantitative and qualitative in nature and are collected or analyzed through various means.

And so, returning to the original question, "How do I train resiliency?," it then becomes essential to identify how resiliency is measured. More critically, do these measurements have meaning and value to the individual and the care provider? Can these measurements be related to feelings, emotions, thoughts, and perceptions, and in this way linked to physiological symptoms and tangible, qualitative measurements? Can an individual be presented with cold, hard, objective measurements that then become the basis for the effectiveness of a program—like measures of performance—as is expected in a contracting process?

B. PURPOSE

As the field of resiliency continues to broaden in its approach, the advancement of technology has presented a unique opportunity to observe how people respond to stress in a longitudinal approach, in the real world, as it were. These advancements have been particularly astounding in the field of wearables, which are capable of monitoring physiological signals at a commensurate level as those of gold-standard laboratory devices. By employing such technologies and training and observing changes through long-standing and validated assessments, the opportunity to quantifiably measure one's resiliency may present itself. If such an association exists, this would then provide individuals and organizations the ability to monitor and proactively identify individuals that may be at risk or may be approaching exhaustion, according to Selye's General Adaptation Syndrome (Selye, 1976). This is not to say that physiological markers should become screening criteria for job performance, but rather provide a means through which an individual can understand and begin to *connect* the three pillars or resiliency through interaction with the environment and one's own physiological sensations and thoughts.

Therefore, this thesis is designed to explore the ability to provide personal, individualized feedback to illuminate measurements of critical components of their state of resilience. For example, one can know that they are in bed for eight hours, but without a device to measure sleep quality, the benefits remain unknown. A care provider can take measurements while the patient is present or may see that individual when they are on duty, but the majority of one's time still remains unobserved. Hence, providing the individual and the care provider with the means to continuously observe physiological measurements allows both to identify periods within which the individual's resilience is compromised. Additionally, this provides the means to proactively and unobtrusively assist the individual in maintaining optimal performance and consequently enhances the force's readiness.

C. COLLABORATION

The thesis advisory group established collaboration with the University of Arizona's Social, Cognitive, and Affective Neuroscience (SCAN) Lab. In exchange for access to assessment results and the ability to utilize "awareness training" as an intervention, the NPS research team recruited additional eligible participants to the SCAN Lab's research. In this way, the NPS research team initiated the research study and collected physiological data, and then handed the participants over to the SCAN Lab for assessments and training.

D. RESEARCH QUESTIONS

At the heart of this thesis is the question of whether the measurements provided by the commercially available ŌURA ring are associated with the subjective assessments of one's stress, resilience, and emotional intelligence. Specifically, do the measured factors of resting heart rate and heart rate variability, as measured by the ŌURA ring, correlate with the assessment scores?

Four sub-questions can help answer the main research question: does the proprietary algorithm which determines "readiness" correlate with subjective resilience assessments? Does an enhanced, quantitative understanding of one's self have a positive effect on the individual? Is the ŌURA ring a viable means to enhance unit-level care to individuals by allowing care providers to notice trends and identify individuals who may be in a compromised or degraded state of resiliency? Are any of the physiological measurements collected by the ŌURA ring reactive to the Emotional Intelligence Training intervention?

E. HYPOTHESIS STATEMENT

I hypothesize that there will be a correlation between the objective, qualitative measures of heart rate variability and the subjective, self-reported assessments that can help augment the individual's understanding of their state of resilience.

F. ORGANIZATION

This thesis is organized into six chapters. Chapter I frames the problem by presenting background on the topics and how they are interrelated. The second chapter presents various models that have been applied historically to the concepts of *stress* and congruently *resilience*, which provides validation of the construct to be utilized for data analysis. Chapter III outlines the method which was utilized to establish the study and collect data. The fourth chapter is an analysis of the data collected. Chapter V presents conclusions from the data analysis interpretation and makes recommendations for further research. Finally, Chapter VI presents recommendations for further research and applications.

II. LITERATURE REVIEW

As the military continues to focus on its forces' readiness, it seeks to help service members cope better with stress. *Resilience* in this construct must first focus on understanding stress and how the body physiologically processes stress. Within these processes, the body presents unique signatures such as heart rate variability that may indicate the individual's ability to cope. Coupled with current emotional intelligence efforts, the following literature review describes and links the topics to understand this research's purpose.

A. STRESS

Before delving into *resilience*, it is first necessary to analyze the primary factor that stimulates or causes resilience: *stress*. *Stress* serves as the response to daily stressors and describes the resultant impacts that create the demand for resilience. As such, it is critical to understand where the term originated, how it is understood in the present day, and the unique stress responses the military lifestyle creates for service members.

1. Origins

Often referred to as the "Father of Stress," Dr. Hans Selye, an endocrinologist by training and trade, dedicated his life to uncovering the body's response to stressors (Selye, 1976). Selye explains that "stress is the nonspecific response of the body to any demand" (p. 15). Moreover, he asserts that one cannot treat stress as a specific or individualized aspect; rather, one must have a holistic and integrative approach. Furthermore, Selye notes that *stress*—being nonspecific—is equally good (*eustress*) and bad (*distress*) in its impact on the organism and is associated with both positive and negative effects. He found that with this macro view as the starting point, one is then subsequently able to examine "*different types of stress*, although the effects of stressors are almost invariably different. There is no 'specific stress'; this expression is a contradiction in terms" (p. 15).

Dr. Selye explains that stress is genuinely unavoidable. Therefore, it is all the more critical to understand it; the act of sustaining life consumes energy, and thus, primal functions such as the heart beating or the functioning of respiration, digestion, or nervous systems still create stress. Selye's seminal work, the General Adaptation Syndrome, was the first to outline how the body explicitly responds to stress. General Adaptation Syndrome describes three stages: *alarm reaction*, *resistance*, and, finally, *exhaustion*. As an analogy, Selye describes the stages, respectively, in terms of human life, namely childhood, adulthood, and senility. In *childhood,* the body has a relatively low resistance and responds excessively to all forms of stimulus—Selye likens this stage to a "call to arms." In the resistance phase, *adulthood*, the individual has adapted to the day-to-day stimulus and has built up resistance to stressors. In the final stage of exhaustion, characterized as *senility* in the analogy, the body is no longer able to sustain the adaptations, and the stressor begins to have lasting effects on the individual.

2. In Modernity

Modern stress research has built upon the foundations of Dr. Selye's four-plus decades of work and continues to illuminate the subject. Today, stress is more concisely considered "a physical property of the ambient environment" (Hancock & Szalma, 2008). Research has sustained the nonspecific characteristic of stress and reinforced its interactive nature (Hancock & Szalma, 2008). Hancock and Szalma explain that stress has three distinct facets: first, the internal response; second, a change to the environment by the individual who is experiencing the stress; and lastly, that the behavior in response to a stressor is reflective of the stress experienced. While this approach is undoubtedly more complex than Selye's, it is designed to represent the interactive and invisible effects of stress in the system more accurately. For example, much of the internal response is hard to measure without engaging with the individual. Hancock and Szalma explain that an individual's physiological and psychological response can be measured using questionnaires and sophisticated equipment; however, that response is not uniform amongst individuals. Furthermore, the authors state that this response's external display is also wholly individualized and will therefore have varying effects and degrees of effects on the type and quality of interactions with others. In the second facet, Hancock and Szalma discuss a "fight" response (from the classic fight or flight) from an individual then impacts the environment and alters the stimulus and thus one's response. Lastly, the authors reference a 1989 study by Hancock and Warm that expounded upon this interactional nature of stress, explaining that typically, a task is the source of stress and that the level of stress caused by that task is reflected in the behavior response of the individual.

3. In the Military

Like the term *stress* and even *resilience*, stress in the military takes on many names such as *battle fatigue, combat stress,* or *soldier stress,* among others (Krueger, 2008). Indeed, Krueger explains that even these terms are debated whether they are stressors or types of stress. However, the author asserts there is no debate that service members are subject to unique and continually evolving stressors and commensurate stress due to occupational demands. Krueger outlines the various physical and psychological stresses and stressors that manifest and are experienced by Soldiers. He highlights the environmental threats and effects of service, essentially highlighting the operation in the extremes of spectrums such as altitude, temperature, noise, acceleration and vibration, among others. The author then relates the environmental with physiological and, ultimately, psychological threats and effects. Throughout his discussion, Krueger points to past data and experiences and asserts the need to create key tenants to consider in the modern era and into the future as the battlefield and tools to wage war continues to evolve. Suffice it to say, the resilience pillars of each service member are significantly taxed by their duties.

B. RESILIENCE

The term *resilience* is perhaps as misused as the term *stress*, which Selye worked so diligently to codify. In the same way that *stress* is often used to label types of stressors, *resilience* has often been used to describe types of resilience, rather than as a holistic concept. Frequently, psychological resilience is expressed as mere resilience, leaving much to be discussed in terms of the other types of resilience. As Wu et al. (2013) and Richardson (2002) explain, many types of resilience contribute to an individual's overall resilience. As a result, Richardson (2002) and others rely on a "biopsychospiritual" construct to incorporate a holistic approach to the individual (Connor & Davidson, 2003). Much as ecological resilience relies upon understanding the interactions occurring externally and internally, each pillar's complicated interplay is critical to understanding resilience (Folke et al., 2010).

1. Spiritual Pillar

From a spiritual context, resiliency is often attributed to an individual's ability to employ a belief or values system that gives meaning to life, regardless of religious practice (Coutu, 2002; Richardson, 2002; Wu et al., 2013). This pillar of resiliency is particularly challenging to impact within a large organization with mixed cultural views, as sensitivity to each becomes imperative for the whole to function and focus on the mission. However, the military does provide ample opportunity for individual growth and development as displayed through the United States Army Chaplain Corps, which is responsible for "spiritual readiness" like its counterparts in the other services (U.S. Army Chaplain Corps, n.d.). From an academic and practical standpoint, given the sensitive and diverse nature of spiritual beliefs, it is challenging to develop a training regime that could significantly and measurably improve resilience through this pillar. While each branch of the military service has developed a creed and value set similar to those discussed by Coutu (2002) that successful companies employ, the creed and value set typically impacts organizational rather than individual resilience. As such, this thesis will not explore the spiritual pillar as a viable option for broad institutionalized training.

2. Psychological Pillar

The psychological pillar has been broadly researched, as is evident from over 70 years of research, much of it focused retroactively on such events as the Holocaust and the development of children in adverse conditions (Coutu, 2002; Meredith et al., 2011; Ungar, 2006; Wu et al., 2013). The majority of the factors are found within the qualitative studies of psychological resilience. Indeed the widely accepted Connor-Davidson Resilience Scale focuses mainly on the psychological and spiritual pillars, allowing professionals to measure these factors (Connor & Davidson, 2003). However, it is difficult to derive a quantitative or measurable status of, or changes within, an individual's psychological resilience. These scales are subjective and rely on the individual's interpretation via self-report and depend on a sufficient mastery of language. Despite this subjectivity problem, extensive programs have been developed and employed by the military, industry, and the medical field to cultivate increased psychological resilience (Coutu, 2002; Meredith et al., 2011; Stanley & Jha, 2010).

Various forms of mindfulness training such as Mindfulness-based Mind Fitness, Battlemind, Mindfulness-based Stress Reduction, and others have emerged as the military continues to develop programs in an effort to improve psychological resiliency (Stanley & Jha, 2010). As a practice, mindfulness is described as being present in the moment and has become a hugely popular practice in recent times (Levinson et al., 2014). A study by Levinson et al. (2014) concluded that one mechanism to evaluate mindfulness, which, until their research, had been mainly a self-reported qualitative evaluation, was through breath counting. While elements of the Levinson team's study are useful, it may fall short in training resilience and lacks applicability in a deployed environment. The challenge of implementing other forms of psychological training with the design of improving individual resilience is the requirement for trained professionals to provide instruction and interpret the results. In the pilot program for Mindfulness-based Mind Fitness Training, only sixteen percent of participants stated they "practiced regularly while deployed" (Stanley & Jha, 2010). This challenge is highlighted as a cultural problem associated explicitly with resource availability by Ungar's (2006) research in austere and varied cultures, similar to deployed or training environments for service members.

3. Biological Pillar

The biological pillar has perhaps received the most attention of late as technological advances makes biological monitoring more accessible outside of a medical or laboratory environment. There is ever-expanding research into genetics to establish the predictability of genetic and hormonal markers (Wu et al., 2013). Additionally, a growing body of research illuminates the brain's ability to adapt in response to stress, specifically increases in functionality and regional size (Silverman & Deuster, 2014; Wu et al., 2013). While both of these research areas offer fascinating developments, genotype research offers little in the way of improving our existing force, potentially serving more as a screening and selection mechanism, a topic that should be approached with great caution. Brain growth in response to stress, such as that seen in stress inoculation training, has been scientifically documented; however, it does not offer a measurable improvement without subjecting individuals to regular brain scans and becomes limited in a similar manner to the psychological pillar—resource availability (Silverman & Deuster, 2014; Wu et al., 2013).

Studies have shown that sleep deprivation negatively affects one's cognitive performance (Selye, 1976), making adaptation and coping more difficult for the individual (Stanley & Jha, 2010). Moreover, research is now discussing stress as a significant cause of inflammation, a biological response of the immune system (Silverman & Deuster, 2014). Silverman and Deuster (2014) point out that sleep is the primary biological mechanism to manage stress, potentially explaining why sleep drive may be elevated during illness. The authors explain that another mechanism to reduce inflammation and increase resiliency is physical fitness, which has also been shown to optimize hormonal response and increase neural plasticity. Here again, we see the connection between psychological resiliency and physiological resiliency. The authors describe how this connection uniquely presents itself in the body's primary stress response systems: the immune system, the autonomic nervous system, and the hypothalamic-pituitary-adrenal axis. Silverman and Deuster (2014) assert that a result of these interactions, which can be witnessed by triggering a 'fight or flight' response, is a change in the cardiovascular system. They emphasize that this change can manifest itself in cardiovascular disease, seen in patients with chronic stress.

Changes in the cardiovascular system resulting from these interactions can also be witnessed in heart rate variability (HRV). HRV is best described as the "beat-to-beat rhythm shift that can be associated with aging, illness, and psychological states" (Bernston et al., 1997). In more recent years, HRV has been determined to be a measure of the autonomic nervous system's activity and cardiac vagal tone (Hourani et al., 2020). Hourani et al. (2020) explain that greater flexibility to stressors and higher emotional response regulation have been directly correlated to individuals with a higher resting cardiac vagal tone. The authors recently published a study of military reservists, guardsmen, and first responders that linked HRV with mental health, stress, and resilience. HRV is also currently used within sports science to measure stress in an athlete, hence determining what training should be executed given a high or low HRV (Kiviniemi et al., 2007).

The interaction between cardiac functions and brain functions during sleep has been the point of research for several years (Bonnet & Arand, 1997; Cajochen et al., 1994; Stein & Pu, 2012; Versace et al., 2003; Xiao et al., 2013; ŽEmaitytė et al., 1984). This research, along with others, has indicated that cardiac system activity is associated with sleep stage changes and particular sleep stages, driven by parasympathetic and sympathetic system activation or deactivation. Besides illuminating heart rate changes associated with sleep stages, the existing research has also evaluated the utility of heart rate variability as a presentation of the interplay between the two autonomic nervous systems. Sleep presents an opportune time to evaluate this autonomic tone due to the individual's stationary position and less variation in the heart signal (Stein & Pu, 2012). Several factors allow for a more detailed analysis of heart rate variability while sleeping, such as dividing the heart rate into frequencies (Bonnet & Arand, 1997). While these factors are important to consider and assessable within the data collected, they fall beyond the present study's scope. To summarize, the collective research has concluded that a change in heart rate variability accompanies sleep stages, and sleep offers an opportune period to analyze cardiac patterns.

C. EMOTIONAL INTELLIGENCE

Like stress and resilience, emotional intelligence research spans nearly 100 years and has been updated through the years (Smith et al., 2018). Smith et al. (2018) explain that the field focuses mainly on understanding one's own emotions and interactions with others' respective emotional states. The authors explain that measurement of this understanding, or intelligence, has been divided into two distinct categories and subsequent models: the ability model and the trait model. Further, they clarify that the ability model focuses on objectively measuring an individual's capability to perform through interaction and scenario-driven tasks. Alternatively, the authors describe the trait model, which focuses on the individual's ability to subjectively recognize and self-report their emotional conditions. Smith et al. identify the strengths and weaknesses of both models and seeks to offer a new model utilizing neuro-cognition. In the article, the authors evaluate the brain's adaptations in processing and predicting information and discuss the potential to utilize neuroimaging to evaluate/measure the effects of emotional intelligence training. The application of these models has had broad-sweeping effects and connections with heart rate variability, individual and team performance, and has been shown to be trainable via online platforms.

1. Emotional Intelligence Connection with HRV

In conjunction with HRV, perhaps the most promising research has been the advent of emotional intelligence (EI), which is “generically described as the awareness and understanding of emotional information relating to oneself and others, and the ability to use that information to facilitate goal-oriented behavior” (Vanuk et al., 2019, p. 2). Vanuk et al. (2019) detail the extensive research in the holistic view of an individual, and associations have been made between higher EI levels with mental health outcomes and better physical health. The authors explain that one’s ability to function emotionally is governed by the central and autonomic nervous systems’ interaction or cardiac vagal control (CVC). Measurement of CVC—previously described as cardiac vagal tone—such as heart rate variability, are an indication of this relationship between the parasympathetic and sympathetic branches, or tone. When HRV measurements are high, the authors explain that the individual has an increased adaptive response and regulation in mental and physical health. Furthermore, Vanuk’s team states that higher CVC reactivity indicates an increased ability to adapt and respond to psychological and health maladies. The authors argue that resting CVC and its change and controlling emotions are connected to enhanced performance in high-stress environments. Similarly, they point out that a decreased CVC is becoming a commonly recognized biomarker for the propensity of emotion dysregulation. Vanuk et al. propose that cumulative experiences and risk exposure are responsible for deviations in autonomic control. This consideration of the cumulative exposure becomes especially salient when considering the number and type of exposures to risk and stress of a service member.

2. Emotional Intelligence Effects on Individual and Team Performance

Higher levels of emotional intelligence have been shown to correlate positively with higher individual and team performance (Alkozei et al., 2019; Crombie et al., 2009; Laborde et al., 2011; Vanuk et al., 2019). Performance, or coping with stress, in the sense of the team sports is discussed as the ability of individuals to personally and collectively maintain regulation and optimal execution of tasks while subjected to physical, mental, social, and emotional stressors (Crombie et al., 2009; Laborde et al., 2011). From the perspective of individual performance, Alkozei et al. (2019) assessed a sample of individuals' emotional intelligence and evaluated their performance in the Iowa Gambling Task (IGT). The evaluation indicated that improved levels of emotional intelligence resulted in not only improved performance on the IGT, but individuals also arrived at optimal performance faster.

From a team perspective, Crombie et al. (2009) assessed six South African cricket teams' emotional intelligence levels and compared the results against their performance in a national level tournament. The results suggested that team aggregate emotional intelligence levels were associated with team performance. In drawing the connection to the military domain, emotional intelligence presents itself as a potentially critical component in performance. Task execution in the military presents its members with high-stress or high-pressure situations. In these situations, one must perform at high levels as both an individual and a team member. Furthermore, emotional intelligence has also been shown to positively affect leadership ability, an integral element at all levels within the military (Smith et al., 2018).

3. Online Training of Emotional Intelligence

Alkozei et al. (2019) further evaluated the feasibility of delivering emotional intelligence training in an online format in a controlled study that employed a placebo control training program. They measured the emotional intelligence of 59 men and women and split them into two groups, which received three weeks of either the emotional intelligence training or the placebo program via an online platform. Utilizing accepted assessments of emotional intelligence, the Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT) and the Bar-On Emotional Quotient Inventory (EQ-i), the study assessed pre- and post-emotional intelligence scores as well as performance on the IGT. The results indicated that those who had received the emotional intelligence training performed better on the IGT than the placebo group. This study built upon existing evidence that emotional intelligence is malleable, and more significantly, provided sound evidence that training via an online platform had positive effects on individuals.

D. RESILIENCE IN THE MILITARY

In a 2011 report produced by the RAND Corporation entitled "Promoting Psychological Resilience in the U.S. Military," the authors found it difficult to pinpoint an exact definition of resilience or find effective measures for evaluating program success (Meredith et al., 2011). Furthermore, the report's main objective was to evaluate *psychological resilience*, which, as previously discussed, is just one component of a multi-pillar approach. Reminiscent of Selye's (1976) approach to stress, this focus on a singular *type* of resilience does not address the entirety of resilience and indeed neglects the other pillars that are inextricably interconnected with psychological resilience. As evidence of this struggle to identify the impactful components of resilience, the RAND report authors, at the suggestion of their expert-panel, included physical fitness as a factor. A major thrust of the report was to offer a singular definition to the term resilience to aid in evaluating the effectiveness of programs and offer an accepted goal to be sought. While the authors propose a definition, which they consolidated from 122 collected definitions, experts urged them not to do so.

> The expert panelist cautioned against using the term resilience to refer to something substantive that can be taught in and of itself. Instead, they suggested that we use the term to describe response to a specific experience. In other words, efforts should not try to define resilience per se but instead focus on the factors contributing to resilience. (Meredith et al., 2011, p. 19)

In reviewing current literature, no clear definition of resilience has taken hold, nor has consensus been reached in the field, as evidenced by the various types of resilience (e.g., ecological, organizational, psychological, etc.). In addition, no similar report or evaluation of more current efforts within the military with respect to resilience or resiliency was uncovered. From my own service, which began two years before the RAND Report publication, I have only been exposed to one component of one of the programs (the Global Assessment Tool—an annual online requirement). With the support of their sponsors, Meredith's team compiled a list of 77 programs, which they whittled down to 23 programs evaluated by the criteria of the selected 20 factors of resilience. Interestingly, during their investigation, some of the programs were undergoing name changes (e.g., Battlemind), a trend that has continued. Currently, many of the programs, oversight institutions, and efforts have morphed into others or no longer exist (e.g., the sponsor Defense Centers of Excellence for Psychological Health and Traumatic Brain Injury no longer has an active website). Perhaps these changes result from the challenges identified by the program managers who were interviewed who reported the following five challenges: lack of support from command leadership, program resourcing issues, budgetary constraints and limitations to sustain programs, challenges curtailing program content to the military lifestyle, and stigmas associated with mental health. Regardless, the report finds that of the 23 programs that were evaluated, few address all of the factors agreed upon by the expert panel, and even fewer of the programs had empirically evaluated the effectiveness of their programs.

The comparison is commonly made between military service members and high-level athletes, particularly special operations forces. Both groups are expected to perform at peak psychological and physiological states for a typically forecasted or projected event or stressor. Beyond the expected level of performance and cyclical, routine nature of stressors, the comparison begins to unravel. Service members are subjected to several additional stressors that fall outside the realm of cyclical and routine that can be traumatic within the context of their employment. Therefore, the three pillars of resiliency discussed previously are severely and negatively impacted for service members in a training or deployed environment. Sleep, nutrition, and regular exercise are the most easily measured degradations. Psychological and spiritual stressors include being away from family and community in a challenging environment, especially for those in combat where traumatic stressors are also more likely to occur. As such, it becomes difficult for a resiliency training plan to be developed that a deployed service member, in an austere and likely hostile environment, can execute. Many of the proposed or current resilience mechanisms either require extensive resources and support and are therefore challenging to implement or are unable to be measured quantifiable and are therefore unable to show improvement. This lack of quantifiable metrics is the focus of the present research, both for the organization and the individual.

E. USE OF WEARABLES IN STUDIES

While many of the resilience factors are typically measured subjectively, there are areas within the pillars described previously that can be measured objectively. These objective metrics are the thrust of the current research. As discussed, advancements in wearable devices offer an opportunity to collect more data reliably, unobtrusively, and on a routine and longitudinal basis. Within this study, the factors to be collected and focused on are heart rate and sleep, two major components in how the body processes stress and maintains resiliency (Hancock & Szalma, 2008, p. 237; Silverman & Deuster, 2014). A handful of studies have evaluated wearables' effectiveness and accuracy to collect aspects of these two factors and have compared their results against the scientific gold standards. While devices for the measurement of heart rate have been around for years and have yielded highly accurate results, sleep-related measurements and algorithms are still in development and pose particular challenges. However, current wearable technology performs admirably in estimating heart rate and sleep parameters. One such device, the ŌURA ring, is selected for use in the current study.

III. METHODS

The challenges presented by conducting a research study outside of the laboratory are indisputable and are further exacerbated under pandemic conditions. Further complicating matters was the need to use an unfamiliar emotional intelligence training program designed and facilitated by the University of Arizona researchers, a new wearable device (ŌURA ring), and collaboration between the two teams from the research sites (NPS and University of Arizona). The detailed methods for the research are outlined in the following pages.

A. PARTICIPANTS

United States military active duty service members (N = 52) from the Naval Postgraduate School student body volunteered to participate in the study. The NPS Institution Review Board (IRB) approved the study protocol (NPS IRB# NPS.2020.0053-EP4-7-A).

B. PROCEDURES

The following ten sections explain the process utilized for this study, which took place primarily in the digital environment. In-person interactions were minimized to reduce the risk to participants and the research team and adhere to COVID-19 safety considerations. These restrictions presented unique challenges when collecting data, controlling the study, and communicating with participants.

1. Study Design

The study was based on a randomized, double-blind, placebo-controlled approach. This thesis explored the relationships among stress, resilience, emotional intelligence, and physiological signals gathered over several weeks from 52 volunteers, in which half of the participants received Emotional Intelligence Training (EIT) while the other half served as a control group. The study participants wore a commercially available device (ŌURA ring) that collected movement, heart rate, and temperature data, and utilized proprietary algorithms to estimate sleep and sleep stages to develop a holistic physiological health score. Raw data and computed scores from the device were compiled along with a battery of standardized and validated psychological assessments. These assessments were administered before and after the participants received one of two types of "awareness training" (external and internal) via an online platform, SmartSparrow, developed by the SCAN Lab at the University of Arizona. The "awareness training" was randomly assigned to a control group who received a placebo, the external awareness training, and a study group that received the University of Arizona's emotional intelligence training. The second psychological assessment administration was delayed to allow determination of whether the internal emotional intelligence training resulted in an enduring "protective" effect.

2. Pre-Study Setup

ŌURA rings were received, unpackaged, and placed on the charger to ensure a full charge. Additionally, each ring was paired with an NPS research team email account, which allowed the research team to update the firmware on each ring before issuing them to participants. Updating the firmware before using the rings reduced the number of steps undertaken by each participant and ensured each ring used the same firmware. During this update, the MAC address for each ring was annotated on the exterior box as the only means to track the ring for accountability purposes. The MAC address and the ring size were then collected in a Microsoft Excel file for record-keeping purposes. After updating each ring, the rings were reset to the factory settings to ensure that the wearable was put into low power mode, did not collect any data, and ensured no data had been stored.

3. Recruitment and Enrollment

Two methods were used to recruit participants. The first method included a message placed on the NPS Muster Page with a subsequent link to a recruitment flyer. The second method was an email sent directly to the Defense Analysis Department's current members with a flyer. The recruitment post, email, and flyer focused on performance optimization and referred to the ŌURA ring and "awareness training."

Once participants expressed interest in the study using the link provided in the recruitment flyer, they were sent an email providing the Informed Consent Form, an executive summary of the study, and the ŌURA Teams Terms of Service and Data

Processing Terms, along with a second link to fill in the Study Enrollment Form (pre-study questionnaire). The Study Enrollment Form was hosted using Microsoft Forms on the Naval Postgraduate School's internal Office 365 and required the participants to authenticate their student credentials before accessing the form. A study identification number was assigned after submitting the form, and a study email account was requested utilizing the same identification number.

Once a study email account was assigned, the individuals were notified of their study email, and a link was sent to the prospective volunteers using the study email account to arrange for a sizing appointment. Sizing appointments, lasting ~15 minutes in duration, were utilized to minimize face-to-face contact and adhere to severe acute respiratory syndrome-2, novel coronavirus 2019 (COVID-19) guidelines. Participants signed up for an appointment using a Microsoft Excel spreadsheet, again hosted within the NPS SharePoint site and requiring authentication to access. A member of the NPS research team confirmed the appointment and sent instructions and directions with a follow-up email. Participants were instructed to a) download the ŌURA application to their mobile device; b) check to make sure they had access to their study email account on their mobile device; c) have their NPS credentials and be able to access NPS SharePoint on their mobile device; and d) bring their mobile device with them. Additionally, participants were instructed to wear an appropriate face covering and utilize hand sanitizer before entering the Human Systems Integration Lab.

4. Sizing, Account Registration, and Application Setup

Upon entering the Human Systems Integration Lab and sanitizing their hands, participants were asked to provide Informed Consent by signing an Informed Consent Form. Following the consent process, the participant used the sizing kits provided by ŌURA to determine the size ring needed. They were instructed that the ring could be worn on any finger and on either hand. Once a participant tried on a sizing ring, they placed the ring on the table to be sterilized by the NPS research team following sizing completion. It was explained that the ring should fit comfortably but not able to fall off the finger. Once a size was determined, the research team member retrieved an actual ring from a separate room.

Participants were then asked to access Wi-Fi and open the ŌURA application on their phone while the NPS research team member unboxed the ring and charger, plugging the charger in and placing the ring on the charger. The participant then created an account using the study email account and a prescribed password and consented to the ŌURA Application terms. The NPS research team member verified the MAC Address and size of the ring before the participant completed pairing the ring with the application via Bluetooth. The participant was then walked through setup by allowing notifications, not allowing connection to Apple Health or Google Fit, not allowing workouts to be imported, and bypassing the customization of the application (My Current Goal, My Sleep at the Moment, and Things Affecting My Sleep). The NPS research team member verified the input of biographical information, ensuring that the participant entered January 1st and their actual birth year (as long as this was not the actual birth date, in which case January 2nd was used). Participants were allowed to input their actual height and weight to allow the algorithms to give them personalized feedback in association with their age. Once the application setup was complete, the NPS research team member walked the participant through viewing the connection with the ring, cautioned that airplane mode required the charger to wake the ring, and showed them the reset functions for troubleshooting purposes. Additionally, the NPS research team member verified that the information was input accurately during setup by checking the My Profile and Settings sections within the application's Menu. The NPS research team member also sent an invitation to the participant's study email account from ŌURA Teams once pairing and application setup were complete.

Next, participants were instructed to open the email confirming their appointment and follow the provided link to another Microsoft Form, again hosted within NPS SharePoint and requiring authentication. This form collected affirmation from the participant that they would return the ring when they completed, failed to complete, or withdrew from the study. Additionally, the form collected information regarding which ring size, finger, hand, and hand dominance the ring would be worn. Moreover, a picture of the box which provided ring size and MAC Address was collected as a means of accountability.

Lastly, participants were instructed to access their study account and follow the links verifying their email address with ŌURA on the Web and accept the invitation to ŌURA Teams generated by the NPS research team member. Participants were asked to sign-in to ŌURA on the Web to ensure they remembered their credentials and provided them the opportunity to store them on their device or take note of them. An NPS research team member also explained the functionality of ŌURA on the Web and ŌURA Teams as the means to collect their data and monitor their participation throughout the study.

5. Instructions

Once completing these steps, the NPS research team member explained battery life and charging recommendations of every three-to-four days. Participants were instructed that the time of day they charge the ring was less important than ensuring the ring was charged for overnight capture. The NPS research team member explained that the app would notify the user when the ring's battery was critically low and that the charge time was 60–90 minutes. Additionally, the NPS research team member instructed the participants to regularly confirm that the ring's flat portion (Heritage variant) stayed on top to ensure the sensors were aligned correctly under the finger. Participants' questions regarding the ring were answered as required. Finally, the NPS research team member explained the timeline and process for establishing a baseline with the ring, handing over for the University of Arizona portion of the study, taking the baseline assessments, completing the online training, and a general timeline for the reassessment period.

6. Monitoring and ŌURA Baseline Establishment

Over the next week, a member of the research team verified that participants were uploading their data to their ŌURA account and that there were no issues with data collection via ŌURA Teams. NPS research team members looked to ensure there were not consistent breaks in the data collection that may indicate incorrect sizing or issues with the participants' understanding of the requirements (regular wear, uploading, charging, etc.). On or about the 6th day of data collection, the "HRV Balance" feature would populate for participants under the daily "readiness," signaling that the initial stages of the baseline had been established. At this time, the NPS research team member indicated to the participants that their baseline had been established, and they were ready to transition to the online assessment phase of the study. Once participants acknowledged that they were prepared to transition, their study email account was provided to the University of Arizona research team, who sent instructions for the next phase of the study. In addition to advancing the participant to the next phase of the study, this allowed the two-week baseline establishment to roughly coincide with the completion of the subjective assessment baseline, ensuring that a baseline was established before the "awareness training" was administered (ŌURA, n.d.).

7. Baseline Assessment Phase

Each participant began the online assessment phase on a Monday and was given instructions on accessing each of the three assessment platforms. Participants were given one week to complete the assessments in a single, three-hour period. Upon completing the assessments, the participants were given instructions on how to access the online "awareness training" to which they had been randomly assigned, which became available on the following Monday.

8. Online "Awareness Training"

Participants were provided instructions on how to access the "Awareness Training" and given three weeks to complete the entire course. Both the "internal" and "external" courses were designed to require roughly the same amount of effort and work, approximately 10 hours to complete. The self-paced, self-administered training was started and stopped at the participant's convenience within the three-week window.

9. Post-Training Phase

After completing the "awareness training," participants were required to continue to wear the ŌURA ring and upload their data to the cloud-based platform. No additional requirements or instructions were provided.

10. Reassessment Phase

As determined by the University of Arizona SCAN Lab's study design, approximately 63 days from the start of the initial assessment phase, the participants were contacted again to begin their one-week window for reassessment. Each participant was provided instructions to access the three online platforms and complete the three-hour assessment within the week. Additionally, they were provided with the post-assessment questionnaire to provide information on which, if any, and frequency of stress management techniques they used, learned from the course, or otherwise.

C. APPARATUS

This study employed new technologies and equipment, the ŌURA ring, and long-standing, validated tools to capture a holistic picture of each participant. All of these metrics were delivered or captured via online platforms, thereby reducing the in-person interaction. The following section explains the questionnaires, the assessments, the ŌURA ring, and the online platforms used to collect data and verify study compliance.

1. Questionnaires and Assessments

The pre-study questionnaire included demographic items regarding the individual's branch of service, military occupational specialty, academic department, mobile device operating system, and anticipated graduation date. The assessments were self-administered utilizing three online platforms: Multi-Health Systems, Inc. (mhsassessments.com) for the administration of the MSCEIT, and Psychological Assessment Resources, Inc. (parinc.com), and Qualtrics for the administration of all others. The participants retook the assessments, again in a single, three-hour sitting utilizing the same three online platforms. The assessments follow:

1. Beck Depression Inventory-II (BDI-II): The BDI-II is a self-reported 21-item inventory for adolescents and adults that utilizes a two-week period to assess depression. The scale is rated from a 0 to 63 scale, with a higher score indicating more depression (Beck et al., 1996).

2. Buss-Perry Aggression Scale (BPAQ): The BPAQ is a 4-scale questionnaire assessing physical and verbal aggression, hostility, and anger, respectively. Scales for each subcategory differ, however, lower scores uniformly are better. Physical and verbal aggression scores range from 9 to 45 and 5 to 25, respectively. While anger and hostility scores range from 7 to 35 and 8 to 40 (Buss & Perry, 1992).

3. Connor-Davidson Resilience Scale (CD-RISC): The CD-RISC is a 25-item inventory assessing one's stress coping ability on a 5-point scale. Scores range from 0 to 100, with a higher score being better (Connor & Davidson, 2003).

4. Difficulties in Emotion Regulation Scale (DERS): The DERS is a scale which assesses emotion dysregulation within four dimensions: (a) cognizance and comprehension of emotions; (b) emotion acceptance; (c) the ability to recognize negative emotions and self-regulate away from them; and (d) employ effective regulation strategies. Scores range from 36 to 180, with a higher score indicating more problems regulating emotions (Gratz & Roemer, 2004).

5. Flourishing Scale: The Flourishing Scale is an 8-item scale that produces a single psychological well-being score by assessing a self-reported perception of optimism, self-esteem, purpose, and relationship success. Scores range from 8 to 56, with higher scores being better. (Diener et al., 2010).

6. Inventory of Interpersonal Problems (IIP-32): The IIP-32 is a shortened 32-item version of the Inventory of Interpersonal Problems (IIP) assessing interpersonal relationship difficulties. Higher scores on the IIP-32 are worse (Horowitz et al., 2000).

7. Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT): MSCIET is a performance-based assessment that utilizes scenario-derived tasks to test an individual's abilities to objectively employ Emotional Intelligence.

Higher scores on the MSCEIT indicate better emotional intelligence (Mayer et al., 2002).

8. Multidimensional Scale of Perceived Social Support (MSPSS): The MSPSS is a self-report measure of subjectively assessed social support evaluated in terms of one's intimate, familial, peer relationships. Scores on the MSPSS range from 1 to 7, with a higher score being better (Zimet et al., 1988).

9. Maslach Burnout Inventory - General Survey (MBI-GS): The MBI-GS is a 22-item questionnaire designed to assess the three components of burnout syndrome. Scores on the MBI-GS range from 0 to 6, with a higher score being better (Maslach et al., 1986).

10. Patient Stress Questionnaire (PSQ): The PSQ is a mental health screen which combines the Patient Health Questionnaire-9 (PHQ-9) (Kroenke et al., 2001), Generalized Anxiety Disorder-7 (GAD-7) (Spitzer et al., 2006), Primary Care PTSD Screen (PC-PTSD) (Prins et al., 2004), and the Alcohol Use Disorders Identification Test (AUDIT) (Saunders et al., 1993). Each scale varies in range, however the bottom of the range for all is 0 and is better.

11. Perceived Stress Scale (PSS): The PSS-10 is a 10-item instrument that assesses the extent to which individuals perceive stress within their life. Scores on the PSS-10 range from 0 to 40, with a higher score indicating higher levels of stress (Cohen et al., 1983).

12. Personality Assessment Inventory (PAI): The PAI is an extensive 344-item personality inventory comprised of four validity, 11 clinical, five treatment considerations, and two interpersonal scales. (Morey, L.C., 1991, 2007).

13. Positive and Negative Affective Schedule (PANAS): The PANAS is two, 10-item scales developed to assess the degree to which feelings and states

of Positive and Negative Affect are experienced. Both scales range from 10 to 50, with a higher score being better (Watson et al., 1988).

14. Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5): the PCL-5 is a self-report inventory assessing the symptoms of PTSD in an individual. The PCL-5 inventory score ranges from 0 to 80, with a lower score being better (Blevins et al., 2015).

15. Professional Quality of Life Scale (ProQOL-5): The ProQOL-5 is a self-report measure of those professional helpers that work with individuals coping with trauma. The scale assesses the positive and negative effects, compassion satisfaction and compassion fatigue, respectively, experienced by the care provider. Compassion Fatigue is further assessed in two sub-parts: Burnout and Secondary Trauma Stress. Scales range from 10 to 50, with a higher score being better (Stamm, 2010).

16. Psychological Well-Being Scale (PWB): The PWB is a scale measuring six aspects of well-being and happiness. The PWB scale ranges from 7 to 49, with a higher score being better (Ryff, 1989).

17. Satisfaction with Life Scale (SWLS): The SWLS is a 5-item scale designed to measure an individual's perceived life satisfaction. The SWLS ranges from 5 to 35, with a higher score being better (Diener et al., 1985).

18. Self-Rated Emotional Intelligence Scale (SREIS): The SREIS is a self-reported scale that uses the MSCEIT's emotional abilities as a foundation. The SREIS ranges from 1 to 5, with a higher score being better (Brackett et al., 2006).

19. Social Adjustment Scale-Short Report (SAS-SR): The SAS-SR is a self-report measure derived from the Social Adjustment Scale, focusing on the Qualitative Categories of Behavior Performance, Interpersonal Behaviors, Friction, and Feelings and Satisfactions assessed in the Role Areas of Work, Social and Leisure, Extended Family, Marital, Parental, and Family Unit (Weissman & Bothwell, 1976).

20. State-Trait Anxiety Inventory (STAI): The STAI is a tool for evaluating both state and trait anxiety using 20 items for assessing each, which has been used to diagnose anxiety and depressive syndromes. The STAI ranges from 20 to 80, with a lower score being better (Spielberger et al., 1970).

21. Suicide Probability Scale (SPS): The SPS is a scale for adolescents and adults, which empirically measures the risk of suicide (Cull & Gill, 1989).

22. UCLA Loneliness Scale: It is a 20-item loneliness assessment, with scores ranging from 20 to 80, where a lower score is better (Russell et al., 1978).

An additional questionnaire was administered at the end of the study to assess the implementation of methods taught in the Emotional Intelligence Training. All participants were asked to provide information on how often they utilized the techniques and any additional techniques to help manage stress. Lastly, participants were provided with the opportunity to provide any other comments or feedback. See the appendix.

2. Masked Email Addresses

The Naval Postgraduate School's Information Technology and Communication Services generated email accounts with the naming convention of "ourastudy##@nps.edu" where "##" represents the participants' assigned study identification number. This email account was utilized as the primary means of communication throughout the study. In addition, this email address was utilized to establish an account with ŌURA to protect the participant's identity further.

3. Physiological Tracking

Movement, heart rate, and temperature data were all collected utilizing an ŌURA ring (see Figure 1). The device was worn on the finger and hand of choice and collected raw data, which was interpreted by proprietary algorithms to assess the individual in three categories: readiness, sleep, and activity. The application then provides or calculates several data points shown in Table 1 from the collection of movement, heart rate, and temperature. Using proprietary algorithms and individualized personal information, the

ŌURA app then makes recommendations to daily routines and habits to optimize these scores and thereby improve one's quality of life. The ring's suite of sensors include accelerometers, infrared light-emitting diodes for photoplethysmography, and thermometers (ŌURA, n.d.).

Table 1. ŌURA Ring Measurements

Readiness	Sleep	Activity
Heart rate variability (max and average)	Total Sleep Time	Activity Score
Resting heart rate(min and average)	Sleep Efficiency	Steps
Body Temperature Deviation	Sleep Stages	Walking Equivalency
Readiness Score	Sleep Score	Activity Calorie Burn
Respiratory Rate	Deep Sleep	Total Calorie Burn
Activity Balance	REM Sleep	Inactive Time
Recovery Index	Light Sleep	Dynamic Activity Goal
Sleep Balance	Wake-up time	Goal Progress
	Ideal Bedtime	
	Time in Bed	
	Bedtime	
	Latency	

Source: https://s3.amazonaws.com/ouraring.com/downloads/oura_press_kit.zip

Figure 1. ŌURA Ring Heritage Variant

a. *Nocturnal Heart Rate and Heart Rate Variability*

To assess "readiness" and determine residual stress experienced by the wearer, the ŌURA ring uses nocturnal heart rate (HR) and heart rate variability (HRV) (Kinnunen et al., 2020; Kinnunen & Koskimäki, 2018). By measuring the HR and HRV during sleep, the device is able to normalize, or, as the authors argue, standardize measurement conditions (Kinnunen & Koskimäki, 2018). The overnight period reduces the number of external factors that may acutely affect HR and HRV (Kinnunen et al., 2020; Kinnunen & Koskimäki, 2018). Additionally, repeated measurements offer the wearer the opportunity to develop a baseline of information by collecting data longitudinally and regularly (Kinnunen & Koskimäki, 2018). This baseline is, therefore, individualized and presents the opportunity for tailored analysis as HR and HRV are influenced by age, gender, hormones, and lifestyle. By creating this tailored analysis, the individual can then consider their current state versus their baseline to evaluate stress instead of comparing to another individual or singular epoch that may have confounding influences (Kinnunen & Koskimäki, 2018).

In an analysis of the ŌURA ring against the gold-standard electrocardiogram (ECG), the ring's nocturnal measurements performed reliably (Kinnunen & Koskimäki, 2018). To measure the heartbeat, an ECG detects the electrical impulses which contact the heart. The time between beats is called the R-R interval, which is how the ECG calculates HRV. As a result of the contraction, a pulse of blood flows through the body (Kinnunen et al., 2020; Kinnunen & Koskimäki, 2018). Using infrared light-emitting diodes, the ŌURA ring detects this pulse as a change in blood volume in the finger (Kinnunen et al., 2020; Kinnunen & Koskimäki, 2018). The detection of this photoplethysmographic (PPG) signal, specifically the time between peak volumes known as inter-beat-intervals (IBI), is how the ŌURA ring measures HRV. In both cases of R-R interval and IBI (see Figure 2), the root mean square of successive differences (rMSSD) is the typical measurement to determine HRV, with a time-domain of five minutes (Bernston et al., 1997; Kinnunen et al., 2020; Kinnunen & Koskimäki, 2018). This time interval and method have been seen as a sound reflection of parasympathetic activation within the autonomic nervous system—an indicator of a relaxed state typically associated with relaxation and recovery (Kinnunen et al., 2020; Kinnunen & Koskimäki, 2018). Both ECG and PPG readings have been found to produce errors as a result of either discomfort from wearing electrodes (ECG) or movement, which causes fluctuations in blood flow (PPG) (Kinnunen et al., 2020). Using mathematical formulas, these signals can be normalized; collecting the signals and analyzing them in five-minute epochs has been shown to increase accuracy (Bernston et al., 1997; Kinnunen et al., 2020).

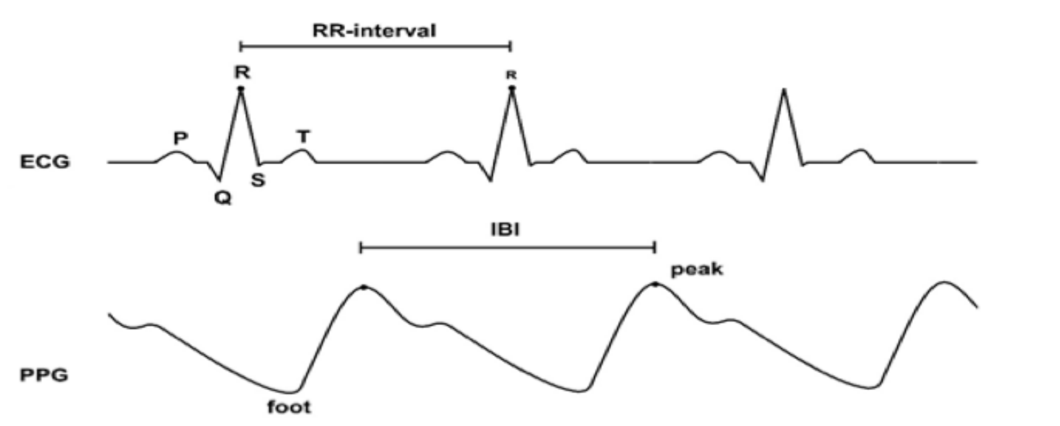

Figure 2. Illustration of ECG-Collected RR-Interval Compared to PPG IBI. Source: Kinnunen and Koskimäki (2018).

In their comparison of ECG R-R interval against the ŌURA ring's PPG IBI (see example in Figure 3), Kinnunen's team (2020) found the ŌURA ring to have a near-perfect coefficient of correlation (r= 0.996) for nocturnal HR and a very strong correlation (r=0.980) for nocturnal HRV. In 2018, Kinnunen and Koskimäki conducted a similar study with a smaller sample size and produced comparable results (HR r=0.999; HRV r=0.984). While the researchers call for continued exploration, the results from both studies indicate that the ŌURA ring is a reliable device for measuring nocturnal HR and HRV. These robust results offer the opportunity to assess stress and resilience, as measured by HR and HRV, within individuals and organizations reliably and continuously.

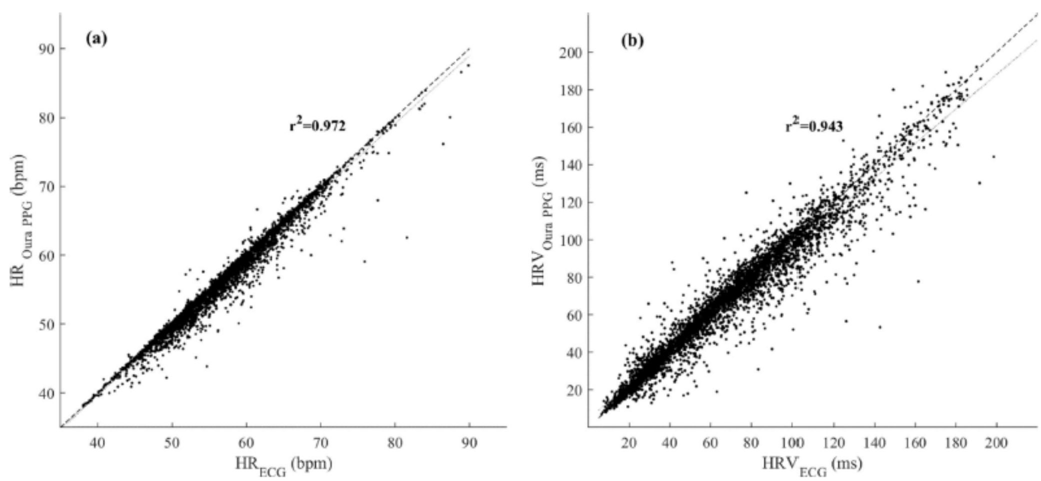

Figure 3. Comparison of HR and HRV Collected by ŌURA Ring and ECG. Source: Kinnunen et al. (2020).

b. Sleep Evaluation

One of the ŌURA ring's primary functions is to analyze the wearer's sleep patterns using algorithms that analyze heart rate, movement, and temperature data (de Zambotti et al., 2019; Kinnunen, 2016). In validation studies, researchers have compared the results of the ŌURA ring against the gold standard polysomnography analysis of sleep patterns (de Zambotti et al., 2019; Kinnunen, 2016). The PSG utilizes up to five signals to determine which stage of sleep an individual is in: electroencephalography (EEG) measures brain waves, electrooculography (EOG) measures eye movements, ECG measures cardiac signals, electromyography (EMG) measures muscle activity, and PPG measures pulse (Kinnunen, 2016). An alternative metric that has been well-established is standard actigraphy, a single sensor collection utilizing accelerometers and algorithms to interpret the data (de Zambotti et al., 2019). Using a combination of sensors and algorithms, the ŌURA ring determines sleep and wake states (sleep onset latency (SOL), total sleep time (TST), and wake after sleep onset (WASO)), as well as sleep stages of deep sleep (equivalent to the PSG N3 phase of sleep), light (PSG N2 and N1 phases), and rapid eye movement sleep (REM) (de Zambotti et al., 2019).

In their study, de Zambotti's team (2019) compared the PSG's standard metrics against the ring's data. A first-generation ŌURA ring was used for the study and produced promising results for evaluating sleep outside of a laboratory setting beyond binary sleep and wake status. The authors reported that in terms of sleep and wake statuses, the ŌURA ring could detect sleep 96% of the time but struggled to detect wake status (48%). Despite the challenges, the ŌURA ring captured 87.8% TST and 85.4% WASO within the accepted ≤30 minutes *a-priori*-set clinically satisfactory ranges. When analyzing sleep stages (see Figure 4), the ring deviated more significantly, accurately capturing 51% of deep sleep (N3), 65% of light sleep (N1 and N2), and 61% of REM sleep.

De Zambotti et al.'s results, as well as the results of ŌURA's internal evaluation by Kinnunen (2016), demonstrate that the ring shows promise for evaluating stages of sleep and wake periods within sleep periods, but improvements can be made. In the 2019 study performed by de Zambotti's team, the ŌURA ring showed significant deviation for the classification of sleep stages, which has posed a significant challenge for non-EEG based systems; however, it did perform well compared to other commercially available devices. The study concluded that the accuracy in detecting total sleep time and the ŌURA ring's overall performance suggests promise for evaluating individual sleep, a key stress management component, in a non-laboratory setting.

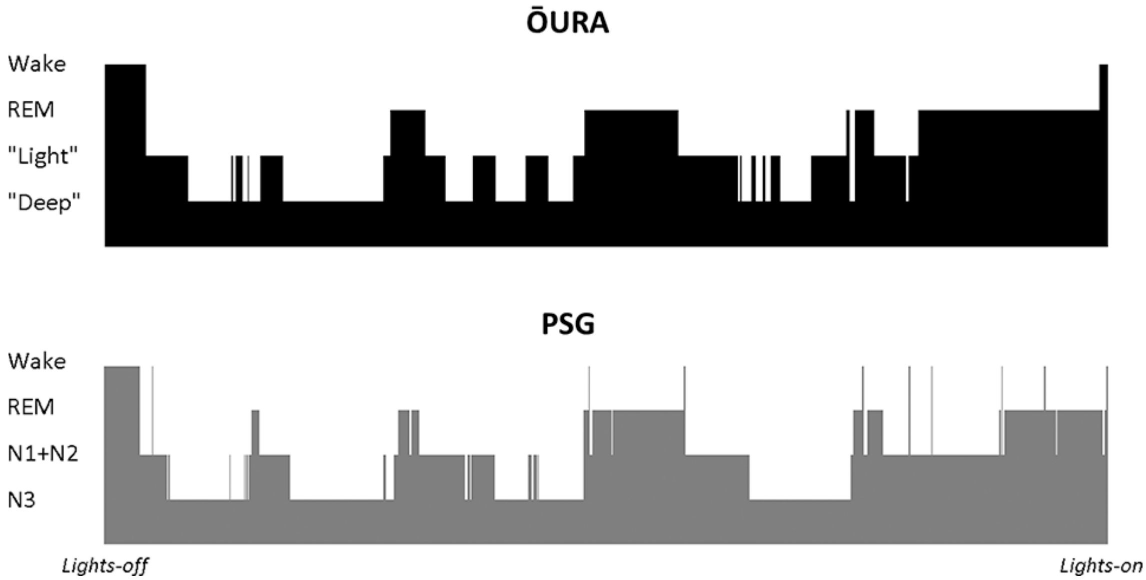

Figure 4. Depiction of Sleep Stage Detection of ŌURA Ring versus PSG.
Source: de Zambotti (2019).

4. ŌURA on the Web, ŌURA Teams, and Researcher Permissions

In conjunction with the mobile device application, ŌURA provides a cloud-based service that allows for further data analysis called ŌURA on the Web, which is simultaneously registered when creating an account. This platform collects the data from the mobile device application and provides the means to conduct cursory data analysis. Furthermore, ŌURA on the Web generates reports in Comma-Separated Values (.csv) and JavaScript Object Notation (.json) files for analysis in external platforms. ŌURA on the Web generates Sleep, Activity, and Readiness data files.

Additionally, ŌURA offers a service known as ŌURA Teams, which allows consenting members to share their data with administrators and "coaches." ŌURA Teams was utilized within the study to merge data from all participants and ensure proper data collection. After completing sizing and account registration, participants were provided a link to share their data and thus allow for remote collection and monitoring throughout the study. ŌURA Teams also provides the ability to export individual and collective data utilizing Comma-Separated Values (.csv) or JavaScript Object Notation (.json) files for external platform data analysis.

Lastly, ŌURA grants researcher permissions to organizations meeting the pre-requisites for ŌURA Teams. These additional permissions grant access to the raw data collected by the ŌURA ring. Specifically, these permissions allow access to temperature, heart rate-heart rate variability (HR-HRV), and inter-beat-intervals (IBI) data files to allow for more detailed analysis.

5. Awareness Training

Two training regimens were used in the study, training on emotional intelligence (the "treatment") and training on the external environment (the placebo). Developed by the University of Arizona's Social, Cognitive, and Affective Neuroscience Lab, both ~10-hour training regimens were self-administered via an online platform, SmartSparrow. Participants were granted access to the training one week after initiation of the first assessment window and given three weeks to complete all training elements. Training could be started and stopped as necessary over the three weeks.

D. ANALYTICAL APPROACH

1. Data Reduction Procedures and Preparation

Preparation for data analysis occurred in three phases. First, all data files from ŌURA Teams were downloaded for each participant and the group. Second, demographic data was compiled from the enrollment questionnaire and assessments. Third, the raw assessment data was collected and evaluated by participant. Participants' answers to individual questions, as well as overall assessment scores, were compiled.

a. ŌURA Data

The heart rate and heart rate variability data extracted from the ŌURA rings were aggregated in five-minute epochs. These data were scrubbed for 0 values (non-reading entries), compiled by sleep period and assigned to the date corresponding with the initiation of sleep, and then averaged to create a singular value for each sleep period. The analysis was based on two metrics, the grand average HRV by sleep episode and the average maximum HRV. Grand averages were compiled for each participant by study phase (baseline, post-training, reassessment).

Raw data from the 44 participants included a maximum of 94 observable days and a minimum of 67 observable days, based upon entry. A total of 3,686 observable days of data were collected from the sample. The average number of observable days per participant was 83.7, with a median of 88 observed days.

b. Assessments and Questionnaires

Questionnaires were collected digitally using Microsoft Forms as per the enrollment process. Data entries were scrubbed for duplicate or non-entry responses. The assessments, administered on three separate online platforms, were cleaned similarly because some participants initiated duplicate assessments. Responses were compiled in Excel spreadsheets and compiled by assessment by participant. Demographic data was contained in both the questionnaire (pertaining to military service) and the assessments (age, gender, etc.) and were compiled in a separate Excel spreadsheet for analysis.

2. Analysis Roadmap

First, we described the study sample in terms of demographic characteristics. Next, we focused on the baseline period and assessments. The baseline assessments were analyzed to describe the study sample and compare it with other relevant populations for which information was available within the literature. The baseline period was defined by the date the participant began to wear the ŌURA ring until the sleep period from the date prior to completing the baseline assessment. The baseline assessments were then compared to the baseline HRV data collected by the ŌURA ring.

Lastly, the analysis was focused on the comparison between the baseline and reassessments (post-training) to evaluate whether any changes had occurred as a result of the training. Furthermore, the analysis was conducted between the HRV metrics at baseline and at reassessment to determine if physiological changes had occurred as a result of training.

Statistical analysis was conducted with JMP statistical software (JMP Pro 15; SAS Institute; Cary, NC). Summary data are reported as mean ± standard deviation (M ± SD).

THIS PAGE INTENTIONALLY LEFT BLANK

IV. RESULTS

Initially, 52 active duty service members volunteered to participate in the study. Three participants did not complete the enrollment process, explaining they were unwilling to volunteer the requisite time for the study. Of the remaining 49, three more withdrew after being assigned study email accounts, and one participant withdrew before beginning the assessments because of discomfort caused by the ring. Additionally, one participant failed to initiate the assessment making their data unusable.

The remaining 44 participants were included in the data analysis. Specifically, 44 participants were included in the baseline assessment analysis, whereas only 36 were included in the reassessment (8 were participants excluded from further analysis because they did not complete the reassessment or did not complete at least 95% of the EIT). Of the 36 participants, 21 were in the *ad hoc* control group, and 15 were in the *ad hoc* treatment group. The ad hoc groups did not fully align with the initial group assignment because two participants never started the training; hence, they were considered part of the *ad hoc* control group.

A. SAMPLE DEMOGRAPHICS (N=44)

Within the 44 participants, there were 6 Air Force, 16 Army, 1 Coast Guard, 8 Marines, and 13 Navy personnel. Thirteen academic departments were represented in the sample, with the Defense Analysis department comprising the largest share. Six of the 44 participants were women, and only one warrant officer and one non-commissioned officer were represented in the sample. The participants were at various stages within their masters' programs at NPS, but all were full-time students. See Tables 2 through 4 for a detailed description of the participant demographics.

Table 2. Participant Demographics

Demographics	
Gender, # (%)	
Men	38 (86.4%)
Women	6 (13.6%)
Age in Years M ± SD	33 ± 4.3
Rank, # (%)	
Officers	42 (95.5%)
Warrant Officers	1 (2.3%)
Non-commissioned Officer	1 (2.3%)

Table 3. Participants by Service

Participants by service, # (%)	
Air Force	6 (13.6%)
Army	16 (36.4%)
Coast Guard	1 (2.3%)
Marines	8 (18.2%)
Navy	13 (29.5%)

Table 4. Participants by Academic Department

Participant by Academic Department, # (%)	
Acquisition Management	1 (2.3%)
Business/Financial Management	1 (2.3%)
Computer Science	4 (9.1%)
Defense Analysis	17 (38.6%)
Defense Management	1 (2.3%)
Electrical and Computer Engineering	4 (9.1%)
Joint Command, Control, Communications, Computers, and Intelligence	1 (2.3%)
Manpower Systems Analysis	2 (4.5%)
Mechanical and Aerospace Engineering	1 (2.3%)
National Security Affairs	6 (13.6%)
Operations Research	2 (4.5%)
Physics	2 (4.5%)
Systems Engineering	2 (4.5%)

B. BASELINE ASSESSMENT

The baseline assessments were collected and analyzed to compare the sample population against the assessments' foundational studies or relevant populations where information was available within the literature.

1. Alcohol Use Disorders Identification Test (AUDIT)

While the Alcohol Use Disorders Identification Test (AUDIT) scores range from 0 to 40 with a lower score being better, traditionally, two cut-off scores (8 and 10) have been used with a high degree of accuracy (Saunders et al., 1993). The average score for the AUDIT was 5.3 ± 3.9 ranging from 0 to 16. Figure 5 shows the distribution of AUDIT scores, and Figure 6 shows the AUDIT categorization distribution. No relevant mean scores were found in the foundational literature review. Of note, 25% of the study population fell into the hazardous/harmful use (scores of 8–10) or alcohol dependent (scores of 10 and higher) categories.

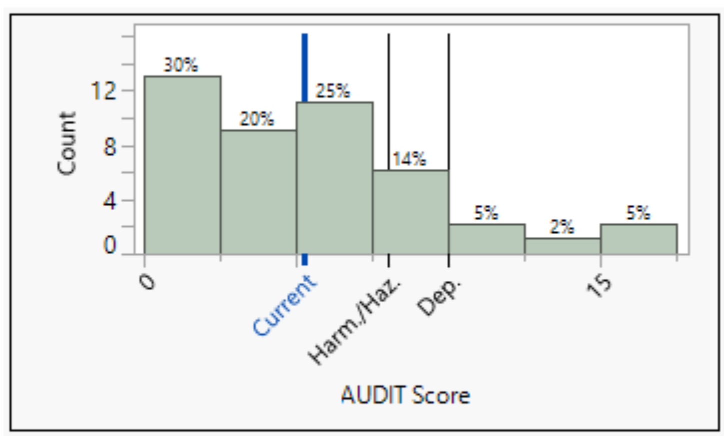

Figure 5. AUDIT Score Distribution.

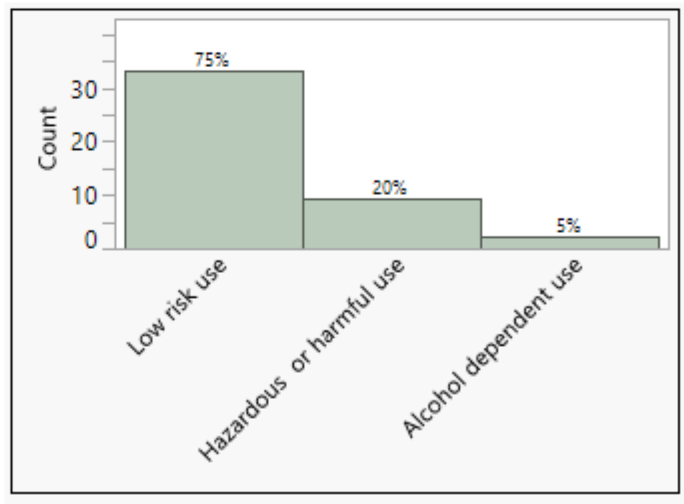

Figure 6. AUDIT Category Distribution.

2. Beck Depression Inventory-II (BDI-II)

The Beck Depression Inventory-II (BDI-II) scale scores range from 0 to 63, with a higher score indicating more depression (Beck et al., 1996). In the present study, the average score on the BDI-II was 6.75 ± 6.12 ranging from 0 to 23. This result is substantively lower than a 1996 study of 120 college students, which recorded an average score of 12.6 ± 9.9 (Wang & Gorenstein, 2013). Figure 7 shows the distribution plot of BDI-II scores.

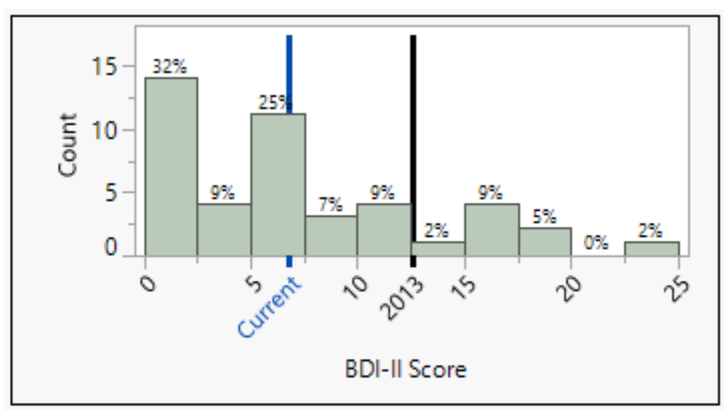

Figure 7. BDI-II Score Distribution.

Ninety-eight percent of study participants were categorized as mild or minimal depression, with the remaining 2% falling into the moderate depression category of the BDI-II. Figure 8 shows the distribution of BDI-II depression categories.

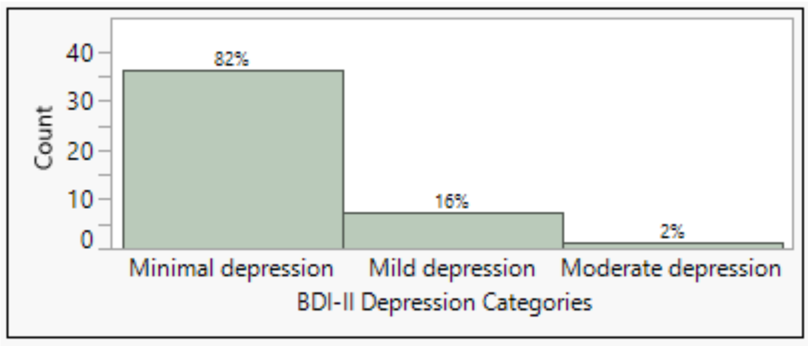

Figure 8. BDI-II Depression Categories Distribution.

3. Buss-Perry Aggression Scale (BPAQ)

The score ranges for each of the Buss-Perry Aggression Scale (BPAQ) subscales vary; however, a lower score is uniformly better (Buss & Perry, 1992). The study's average score for physical aggression (PA) was 20.3 ± 6.0, 11.3 ± 3.8 for verbal aggression (VA), 11.5 ± 3.5 for anger (A), and 13.6 ± 5.3 for hostility (H). Responses ranged from 9 to 35 for PA, 5 to 19 for VA, 7 to 20 for A, and 8 to 29 for H. The average score for the BPAQ Total was 56.8 ± 13.9, ranging from 32 to 91. See Table 5 for Buss and Perry's (1992) and the current study's gender-separated average scores and standard deviations and Figures 9 through 13 for the sample BPAQ distributions. Compared to Buss and Perry's study, the participants in this study scored lower on components of the BPAQ.

Table 5. BPAQ Comparison

	Buss and Perry Study		Current Study	
	Males (n=612)	**Females (n=641)**	**Males (n=38)**	**Females (n=6)**
Scale	**M ± SD**	**M ± SD**	**M ± SD**	**M ± SD**
Physical	24.3 ± 7.7	17.9 ± 6.6	21.1 ± 5.7	15.7 ± 5.9
Verbal	15.2 ± 3.9	13.5 ± 3.9	11.6 ± 3.6	10.0 ± 4.7
Anger	17.0 ± 5.6	16.7 ± 5.8	11.3 ± 3.6	12.5 ± 2.7
Hostility	21.3 ± 5.5	20.2 ± 6.3	13.7 ± 5.5	13.3 ± 4.5
Total	77.8 ± 16.5	68.2 ± 17.0	57.6 ± 13.7	51.5 ± 15.5

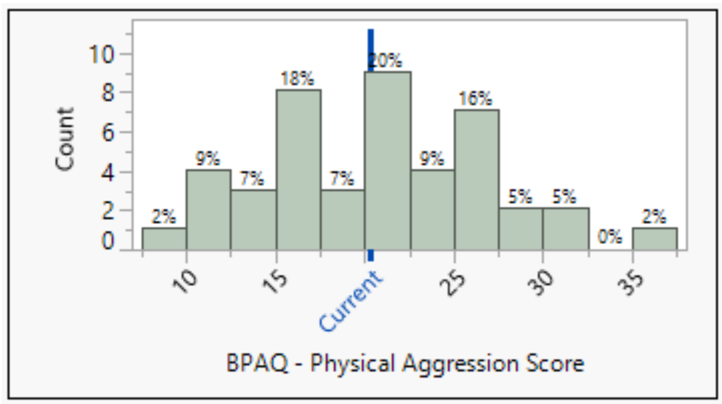

Figure 9. BPAQ—Physical Aggression Subscale Score Distribution.

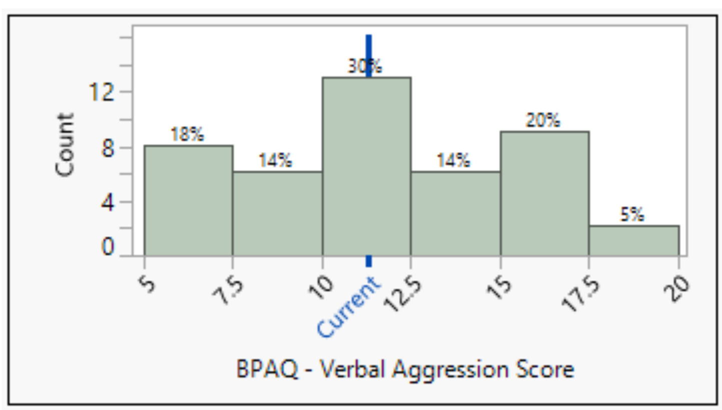

Figure 10. BPAQ—Verbal Aggression Subscale Score Distribution.

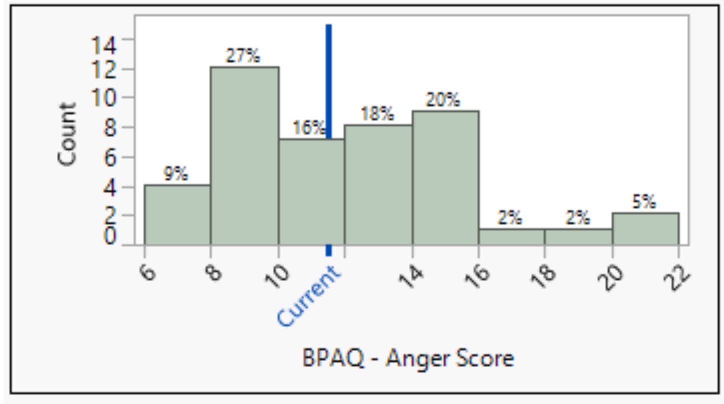

Figure 11. BPAQ—Anger Subscale Score Distribution.

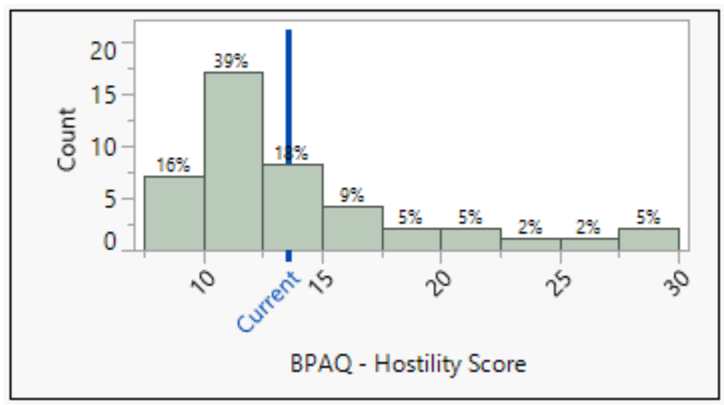

Figure 12. BPAQ—Hostility Subscale Score Distribution.

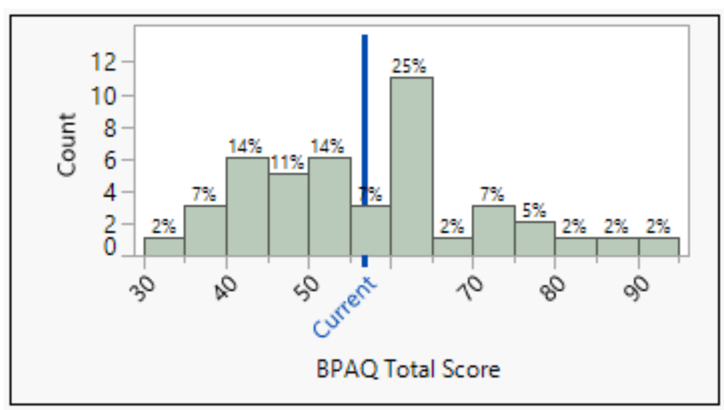

Figure 13. BPAQ total Score Distribution.

4. Connor-Davidson Resilience Scale (CD-RISC)

The Connor-Davidson Resilience Scale (CD-RISC) scores range from 0 to 100, with a higher score being better (Connor & Davidson, 2003). The average score in the current study on the CD-RISC was 78.6 ± 12.12 ranging from 53 to 98, which is consistent with the general population (80.4 ± 12.8, N=577) mean score reported by Connor and Davidson (2003). Figure 14 shows the distribution of CD-RISC scores.

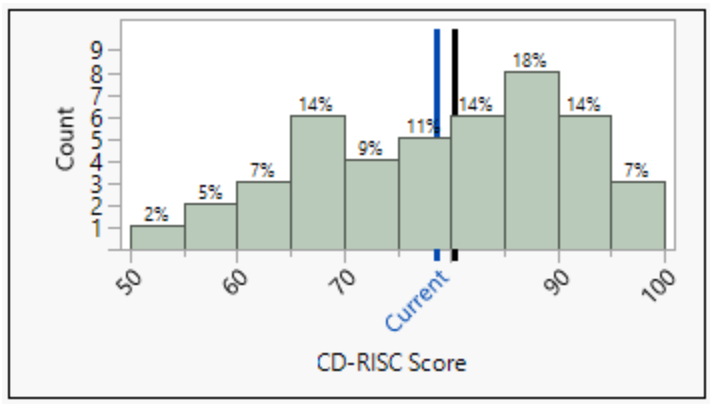

Figure 14. CD-RISC Score Distribution.

5. Difficulties in Emotion Regulation Scale (DERS)

The Difficulties in Emotion Regulation Scale (DERS) scores range from a minimum of 36 and a maximum of 180, with a higher score indicating more problems with emotion regulation (Gratz & Roemer, 2004). The average score in this study on the DERS was 69.3 ± 16.8 ranging from 42 to 108. The mean score in Gratz and Roemer's (2004) study was 77.99 ± 20.72 for females (N=260) and 80.66 ± 18.79 for males (N=97), whereas the present study mean scores were 75.8 ± 18.6 for females and 68.2 ± 16.7 for males. There is a large difference between Gratz and Roemer's average score for men compared to this study. The men in the current study presented an increased ability to regulate emotions. Figures 15 and 16 show the distribution of DERS scores.

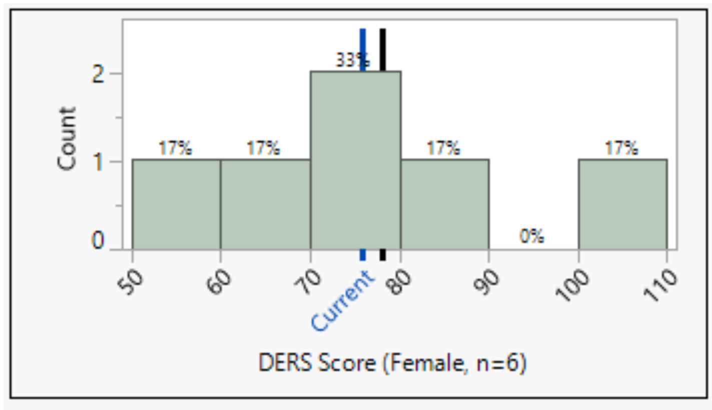

Figure 15. DERS Score Distribution for Females.

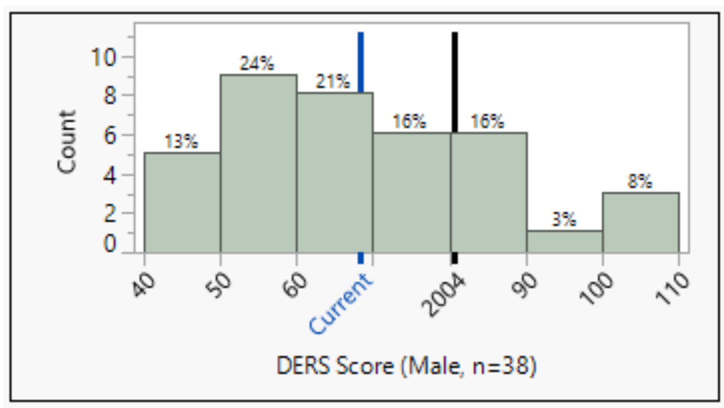

Figure 16. DERS Score Distribution for Males.

6. Flourishing Scale

The Flourishing Scale ranges from 8 to 56, with a higher score being better (Diener et al., 2010). The current study sample's average score on the Flourishing Scale was 48.5 ± 6.5 ranging from 28 to 56, which is relatively consistent with the mean score (44.97 ± 6.56) reported by Diener et al. (2010). Figure 17 shows the distribution of Flourishing scores.

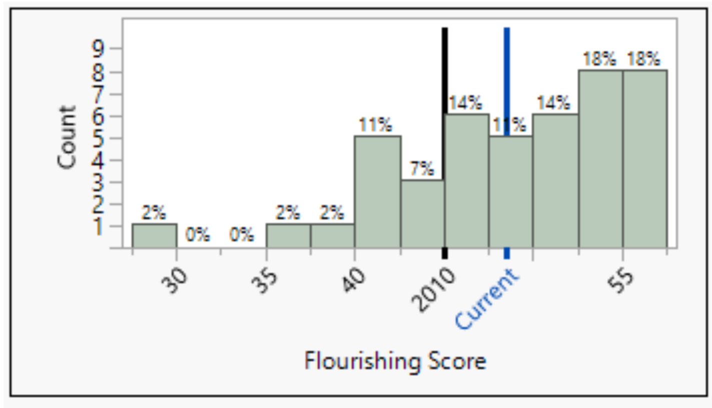

Figure 17. Flourishing Scale Score Distribution.

7. Inventory of Interpersonal Problems (IIP-32)

The average scores and ranges for the eight subscales of the Inventory of Interpersonal Problems (IIP-32) are listed in Table 6. Figures 18 through 26 show the distribution of scores for the IIP-32. No relevant mean scores were found in the literature review. Scores are typically converted into a T-score using 50 as the mean with a standard deviation of 10 (Horowitz et al., 2000). Scores from the present study's sample do not present a significant deviation from the standard scoring.

Table 6. IIP-32 Scores

Subscale	**M ± SD**	**Range**
Domineering/Controlling	47.7 ± 9.3	41 to 76
Vindictive/Self-Centered	49.1 ± 8.2	41 to 65
Cold/Distant	49.4 ± 8.2	52 to 69
Socially Inhibited	50.5 ± 10.8	40 to 75
Nonassertive	53.0 ± 10.8	39 to 83
Overly Accommodating	53.4 ± 12.2	35 to 84
Self-Sacrificing	50.8 ± 10.6	36 to 77
Intrusive/Needy	48.6 ± 8.9	40 to 77
Total	50.7 ± 9.4	38 to 72

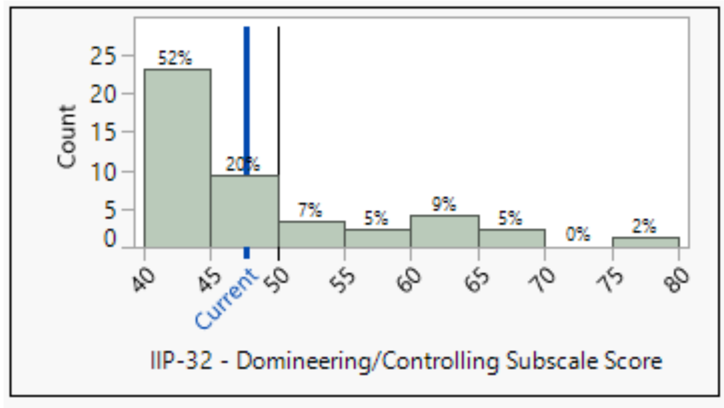

Figure 18. IIP-32—Domineering/Controlling Subscale Score Distribution.

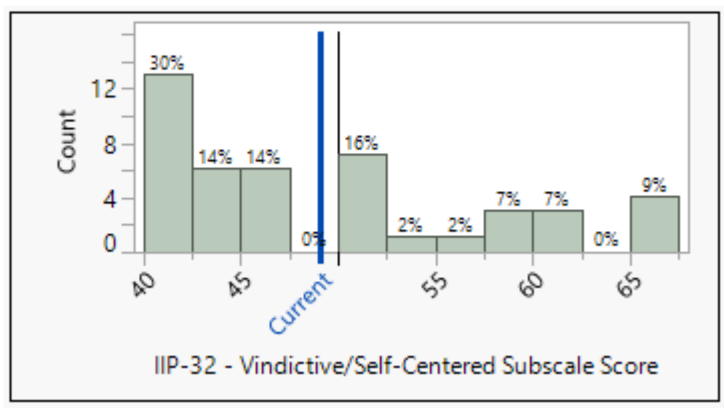

Figure 19. IIP-32—Vindictive/Self-Centered Subscale Score Distribution.

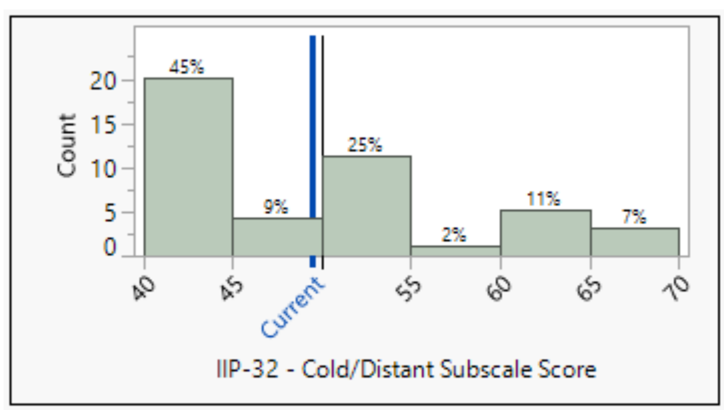

Figure 20. IIP-32—Cold/Distant Subscale Score Distribution.

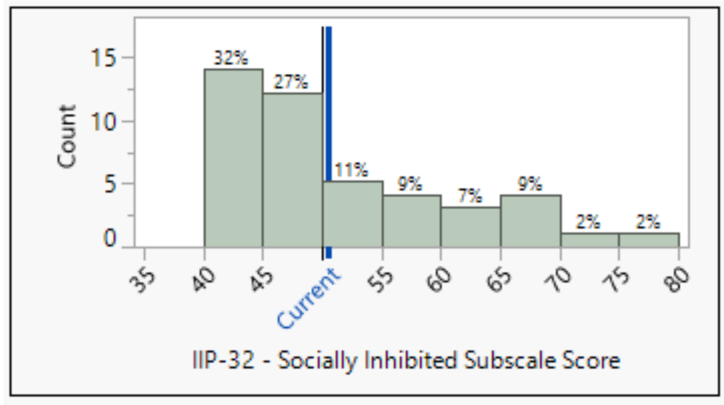

Figure 21. IIP-32—Socially Inhibited Subscale Score Distribution.

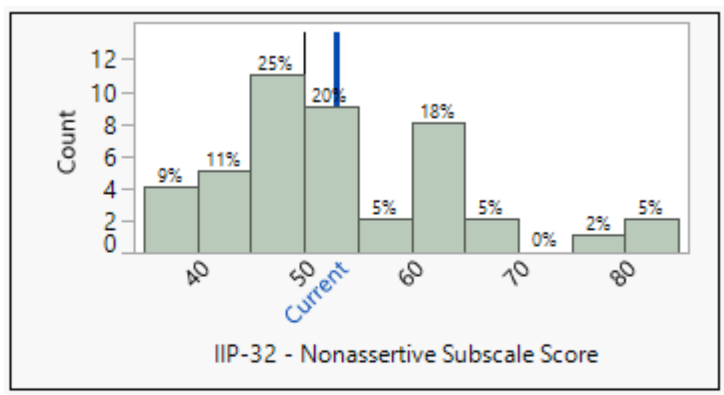

Figure 22. IIP-32—Nonassertive Subscale Score Distribution.

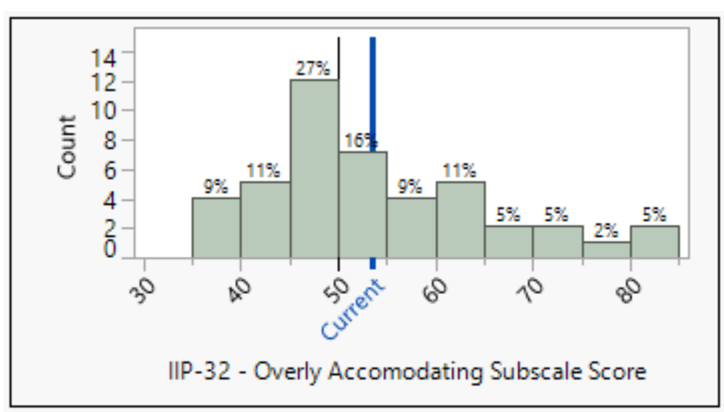

Figure 23. IIP-32—Overly Accommodating Subscale Score Distribution.

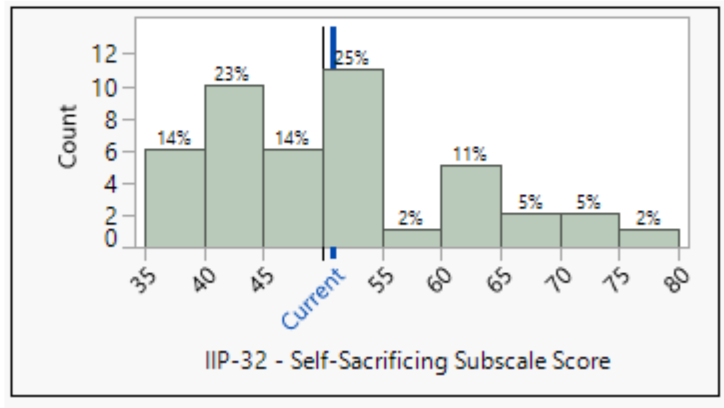

Figure 24. IIP-32—Self-Sacrificing Subscale Score Distribution.

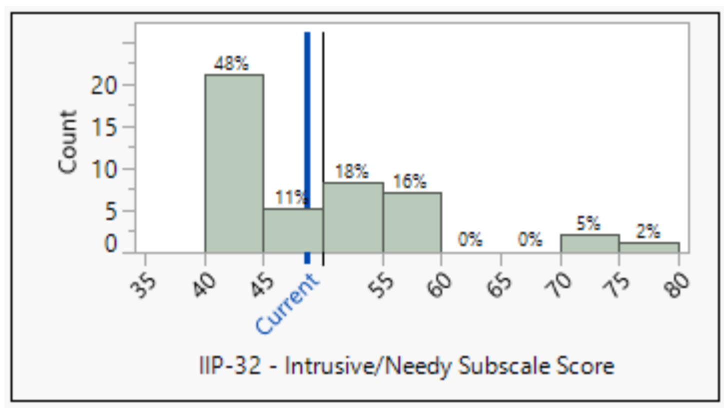

Figure 25. IIP-32—Intrusive/Needy Subscale Score Distribution.

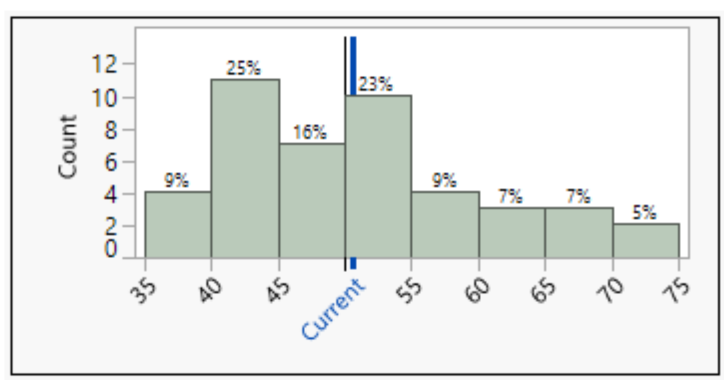

Figure 26. IIP-32 Total Score

8. Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT)

The Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT) is a standardized, normally distributed test with an average score of 100 ± 15, with higher scores indicating better emotional intelligence (Mayer et al., 2003). In the present study, the average total score was 102.2 ± 11.8 ranging from 68.4 to 123.2. The subscales average scores were 113.8 ± 25.1 for perceiving emotions, ranging from 76.4 to 165.8; 101.9 ± 12.8 for using emotions, ranging from 73.8 to 126.3; 101.4 ± 7.9 for understanding emotions, ranging from 75.7 to 118.2; and 97.7 ± 9.6 for managing emotions ranging from 68.7 to 118.3. The distributions for the MSCEIT total score and subscales follow in Figures 27 through 31.

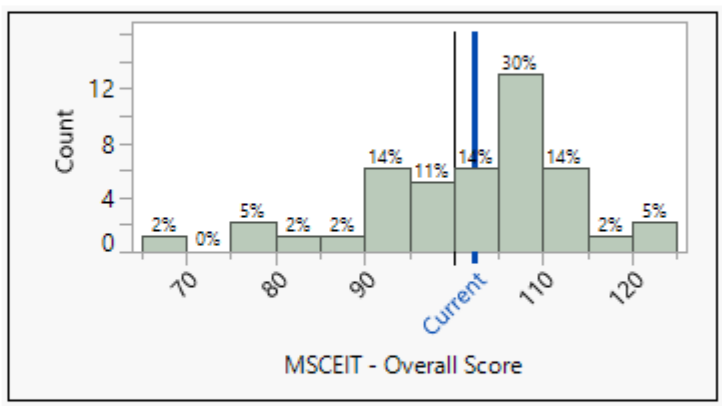

Figure 27. MSCEIT overall Score Distribution.

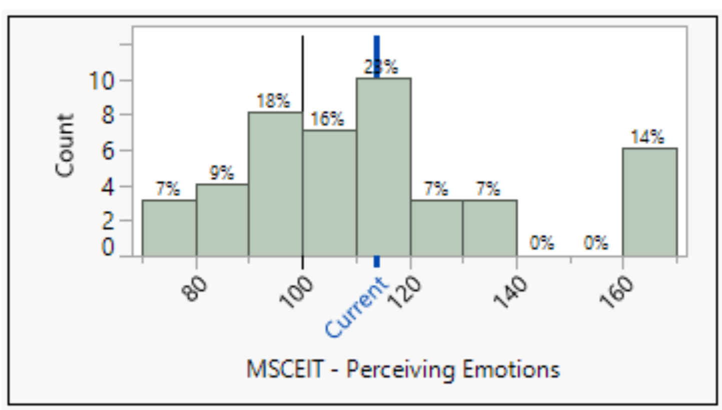

Figure 28. MSCEIT—Perceiving Emotions Subscale Score Distribution.

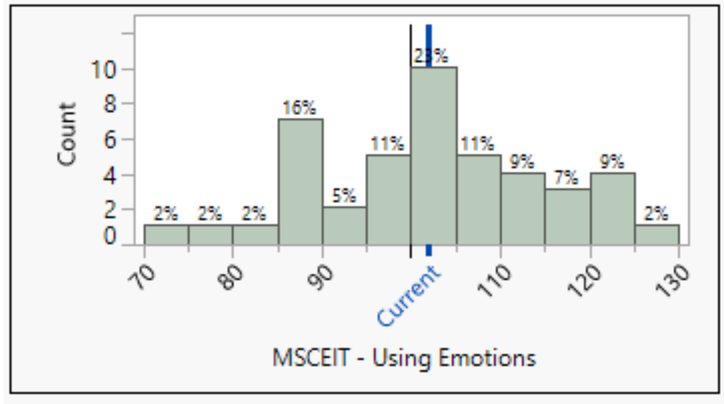

Figure 29. MSCEIT—Using Emotions Subscale Score Distribution.

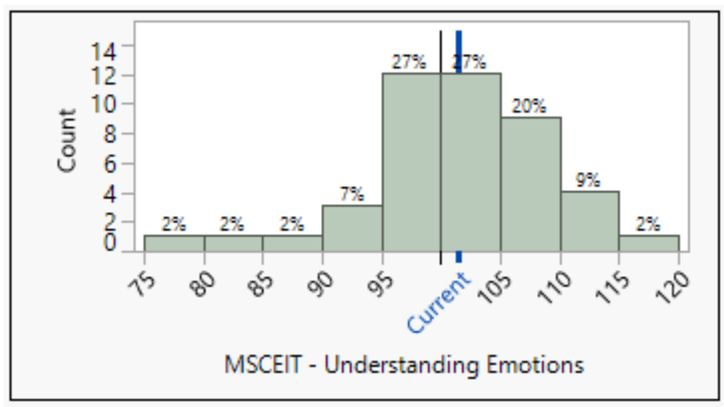

Figure 30. MSCEIT—Understanding Emotions Subscale Score Distribution.

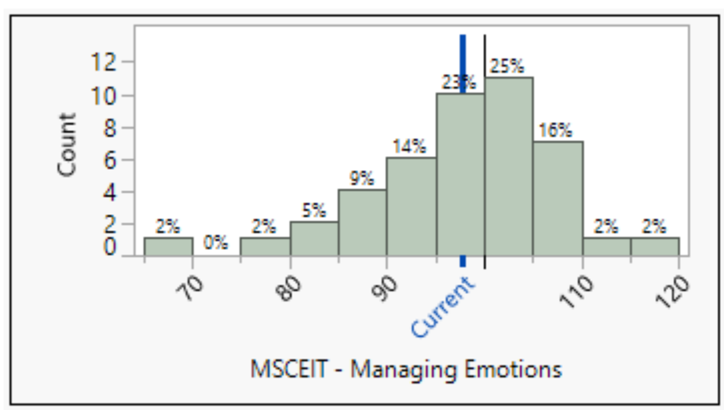

Figure 31. MSCEIT—Managing Emotions Subscale Score Distribution.

9. Multidimensional Scale of Perceived Social Support (MSPSS)

For the Multidimensional Scale of Perceived Social Support (MSPSS), the subscales are uniformly scaled from 1 to 7, with a higher score indicating more perceived support (Zimet et al., 1988). In the present study, the average score for family was 5.9 ± 1.2, for friends was 5.9 ± 1.0, for significant other was 6.3 ± 0.9, and for social support total was 6.1 ± 0.9. Scores, respectively, ranged from 2 to 7, 2.5 to 7, 2.5 to 7, and 3.8 to 7. Figures 32 through 35 show the distributions of scores. Zimet et al. (1988) reported the following mean scores and standard deviations for a sample of 275 undergraduates: 5.80 ± 1.12 for family, 5.85 ± .94 for friends, 5.74 ± 1.25 for significant other, and 5.80 ± .86 for the total score.

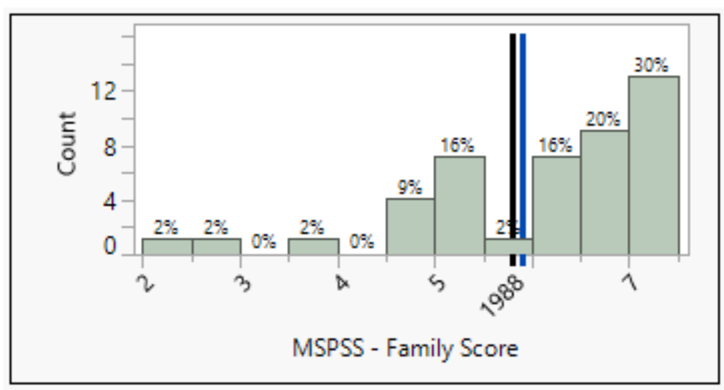

Figure 32. MSPSS—Family Subscale Score Distribution.

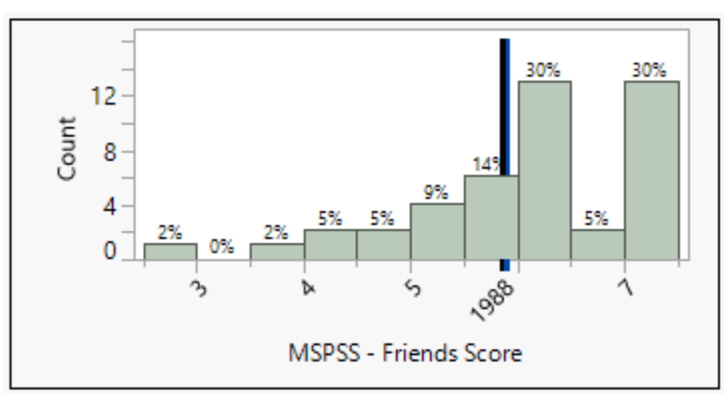

Figure 33. MSPSS—Friends Subscale Score Distribution.

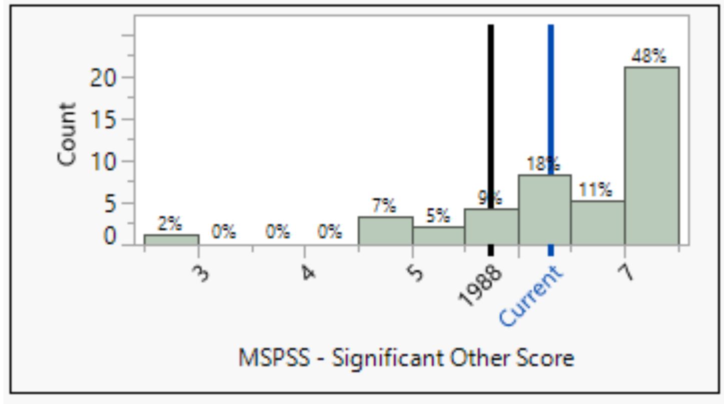

Figure 34. MSPSS—Significant Other Subscale Score Distribution.

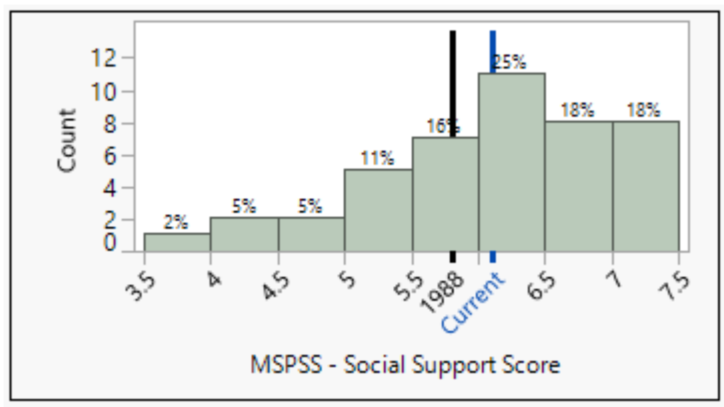

Figure 35. MSPSS Social Support Score Distribution.

10. Maslach Burnout Inventory - General Survey (MBI-GS)

The three subscales of the Maslach Burnout Inventory - General Survey (MBI-GS) are scored on a 0 to 6 scale, with lower scores in exhaustion and cynicism and a higher score in professional efficacy indicating less burnout and therefore a better score (Maslach et al., 1986). This study's average score for exhaustion was 2.4 ± 1.7, 2.1 ± 1.5 for cynicism, and 4.6 ± 1.2 for professional efficacy. Scores ranged from 0 to 5.8 for both the exhaustion and cynicism subscales and 1.2 to 6 for the professional efficacy subscale. Figures 36–38 show the distribution of subscale scores for the MBI-GS. No relevant mean scores were found in the literature review.

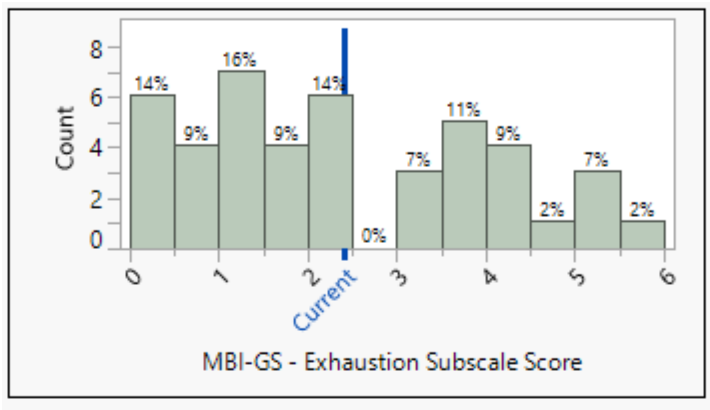

Figure 36. MBI-GS—Exhaustion Subscale Score Distribution.

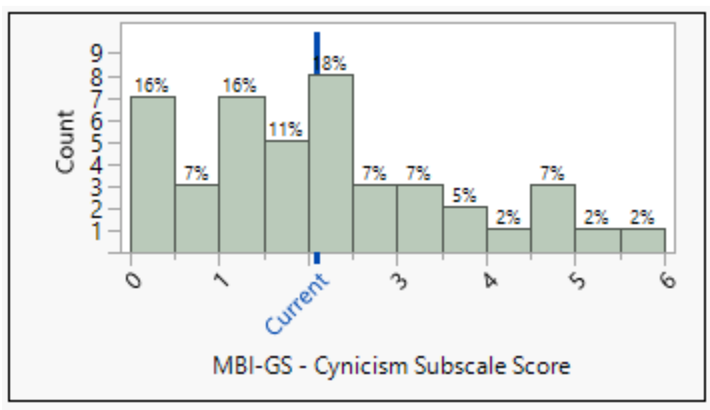

Figure 37. MBI-GS—Cynicism Subscale Score Distribution.

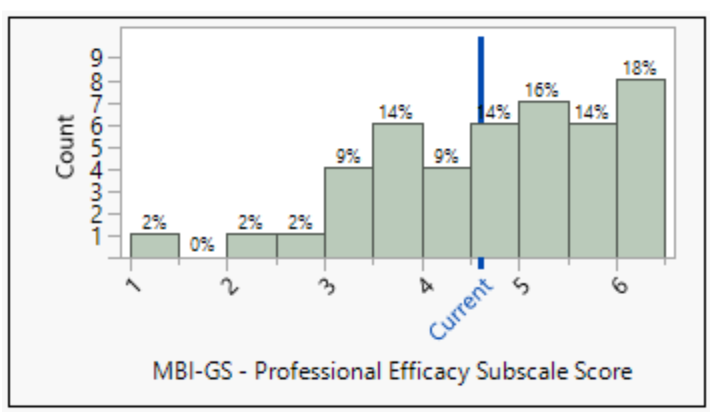

Figure 38. MBI-GS—Professional Efficacy Subscale Score Distribution.

11. Patient Stress Questionnaire (PSQ)

In terms of the Patient Stress Questionnaire (PSQ), the subscales for each have various ranges; however, lower scores on all the subscales are considered better. For the current study's sample, the average score for the depression subscale was 3.7 ± 4.1, 3.0 ± 3.8 for the anxiety subscale, and 0.5 ± 0.9 for the PTSD subscale. Scores ranged from 0 to 18, 0 to 16, and 0 to 4, respectively. Figures 39–41 show the distributions for the PSQ subscales. The pain item's average score was 0.2 ± 0.4, with scores ranging from 0 to 1 (see Figure 42). Kroenke et al. (2001) reported a mean score of 3.3 ± 3.8 for the Patient Health Questionnaire-9 (depression subscale) for patients with no depressive disorder (N=474). Spitzer et al. (2006) reported a mean score of 4.9 ± 4.8 in patients (N=892) without general anxiety disorder (anxiety subscale). Prins et al. (2003) reported a mean score of 1.3 ± 1.6 in a sample of 188 people (PTSD subscale). Participants in the current study scored significantly lower on the anxiety subscale compared to Spitzer's study.

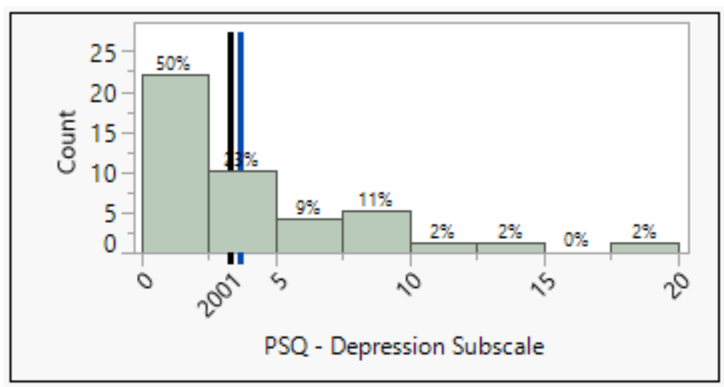

Figure 39. PSQ—Depression Subscale Score Distribution.

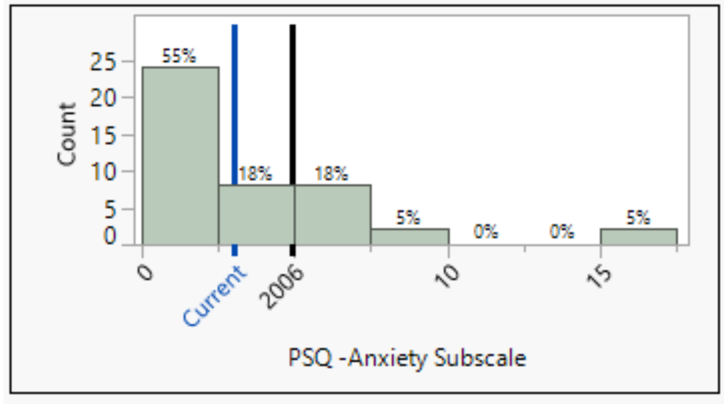

Figure 40. PSQ—Anxiety Subscale Score Distribution.

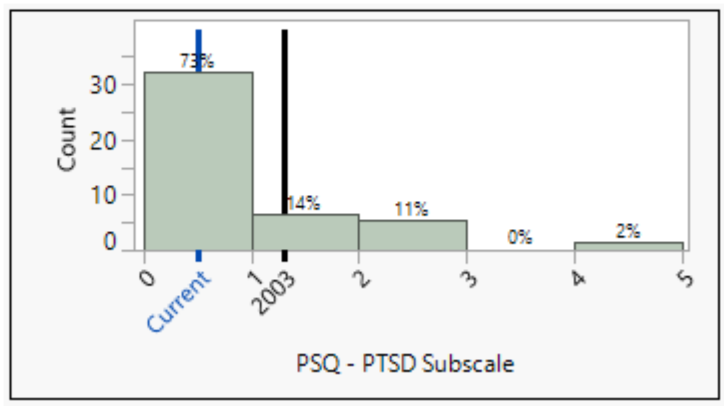

Figure 41. PSQ—PTSD Subscale Score Distribution.

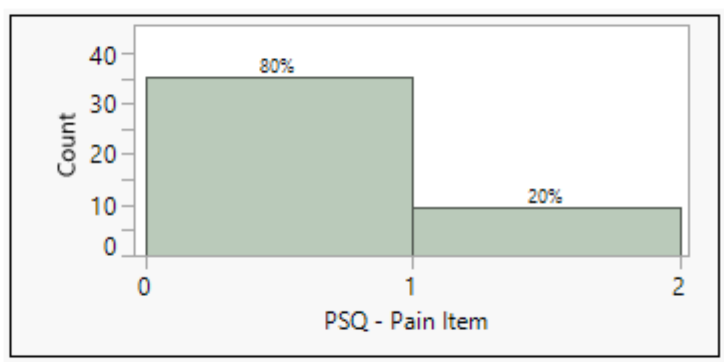

Figure 42. PSQ—Pain Item Score Distribution.

12. Perceived Stress Scale (PSS-10)

The Perceived Stress Scale (PSS-10) is scored on a 0 to 40 scale, where a higher score indicates a higher stress level (Cohen et al., 1983). The sample's average score for the PSS-10 was 12.3 ± 6.8 ranging from 0 to 28. Figure 43 shows the sample distribution of PSS-10 scores. Based on their scores, participants were classified into three categories: low perceived stress (55%), moderate perceived stress (43%), or high perceived stress (2%) (see Figure 46). Cohen et al. (1994) report that the mean scores for the normal population were 23.18 ± 7.31 for males (N = 926) and 23.67 ± 7.79 for females (N = 1406). Comparatively, this study found significantly lower levels of perceived stress with mean scores of 11.4 ± 6.3 for males and 18.2 ± 7.6 for females (Figures 44 and 45). That is, participants in the current study reported significantly lower levels of perceived stress.

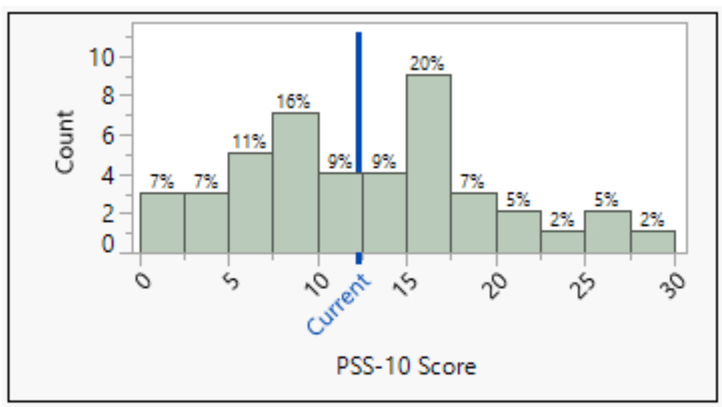

Figure 43. PSS-10 Score Distribution.

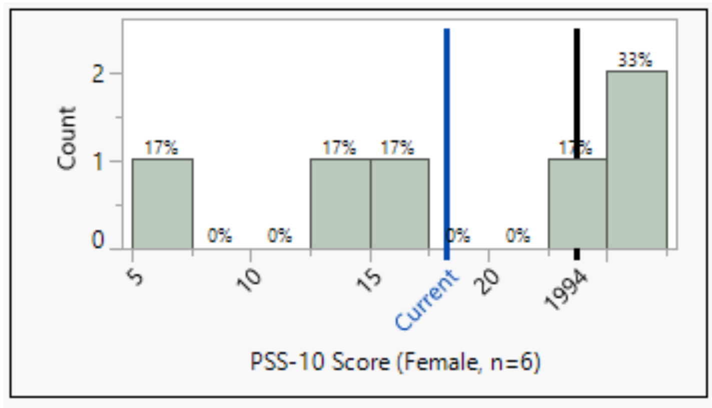

Figure 44. PSS-10 Score for Females.

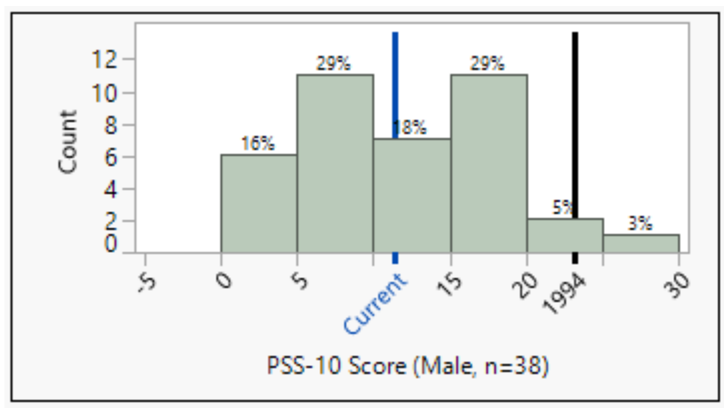

Figure 45. PSS-10 Score for Males.

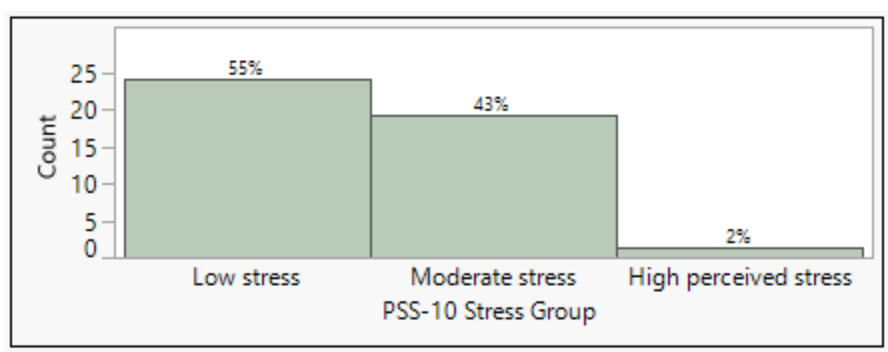

Figure 46. PSS-10 Stress Group Score Distribution.

13. Personality Assessment Inventory (PAI)

The average scores and ranges for each of the 22 scales of the Personality Assessment Inventory (PAI) are listed in Table 7. *T*-scores are generated for each of the raw scale and subscale scores for the PAI using a mean score of 50 ± 10 (Morey & Ambwani, 2008). Figures 47 through 68 show the distribution of scores for the PAI. Deviations from a score of 50 indicate personality deviations from the non-clinical normative population (Morey & Ambwani, 2008). Of note, the current study's stress score is marginally lower but does not fall outside of the standard deviation of 10 to be significant.

Table 7. PAI Scores

Scale	**M ± SD**	**Range**
Inconsistency	47.9 ± 8.5	34 to 74
Infrequency	48.4 ± 5.9	40 to 67
Negative Impression	47.9 ± 7.0	44 to 77
Positive Impression	52.1 ± 10.1	20 to 70
Somatic Complaints	46.6 ± 6.7	39 to 67
Anxiety	46.9 ± 8.1	35 to 70
Anxiety Related Disorders	46.9 ± 7.2	34 to 66
Depression	47.6 ± 10.4	36 to 75
Mania	51.9 ± 7.5	32 to 67
Paranoia	46.8 ± 8.8	33 to 69
Schizophrenia	48.5 ± 9.7	33 to 73
Borderline Features	45.9 ± 8.5	35 to 69
Antisocial Features	45.9 ± 8.5	35 to 69
Alcohol Problems	52.3 ± 7.5	41 to 75
Drub Problems	48.7 ± 7.4	42 to 66
Aggression	46.5 ± 7.6	32 to 62
Suicidal Ideation	46.2 ± 5.3	43 to 68
Stress	44.7 ± 6.7	37 to 64
Nonsupport	46.8 ± 12.3	3 to 80
Treatment Rejection	54.3 ± 8.5	33 to 68
Dominance	52.4 ± 10.6	26 to 70
Warmth	48.8 ± 10.8	21 to 65

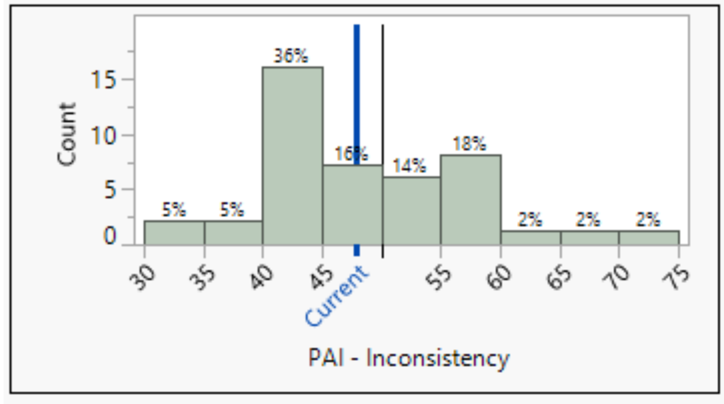

Figure 47. PAI—Inconsistency Subscale Score Distribution.

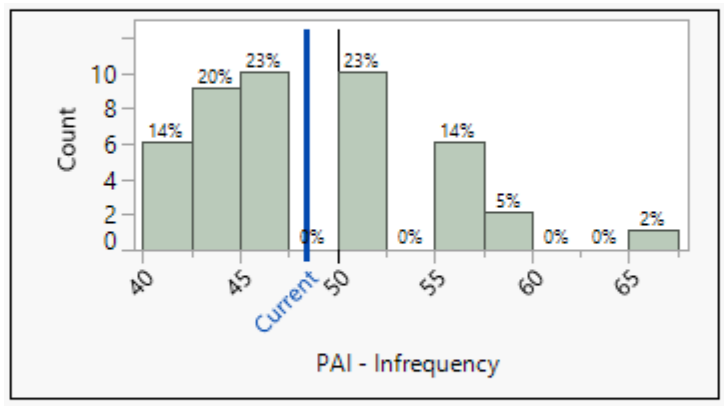

Figure 48. PAI—Infrequency Subscale Score Distribution.

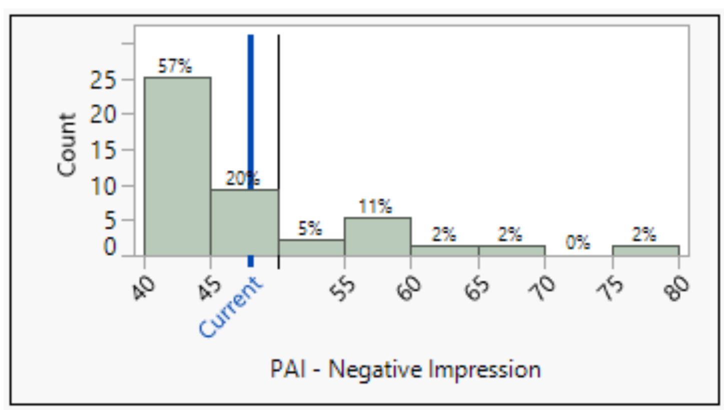

Figure 49. PAI—Negative Impression Subscale Score Distribution.

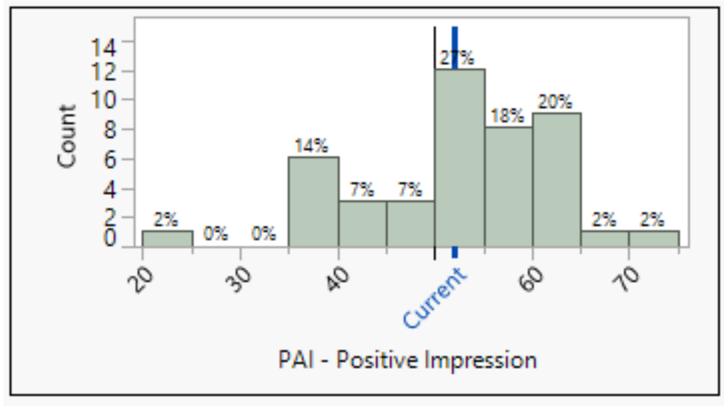

Figure 50. PAI—Positive Impression Subscale Score Distribution.

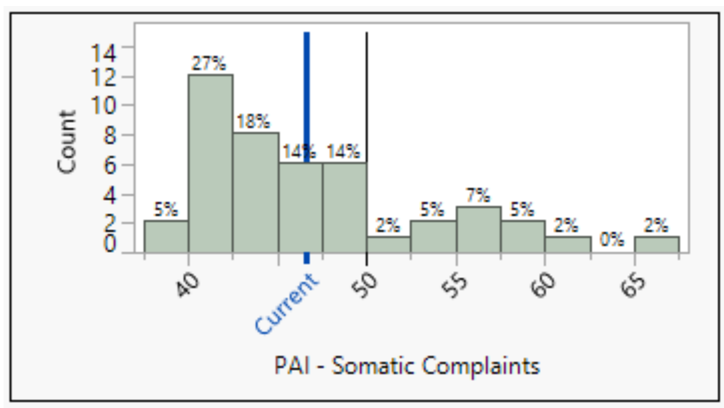

Figure 51. PAI—Somatic Complaints Subscale Score Distribution.

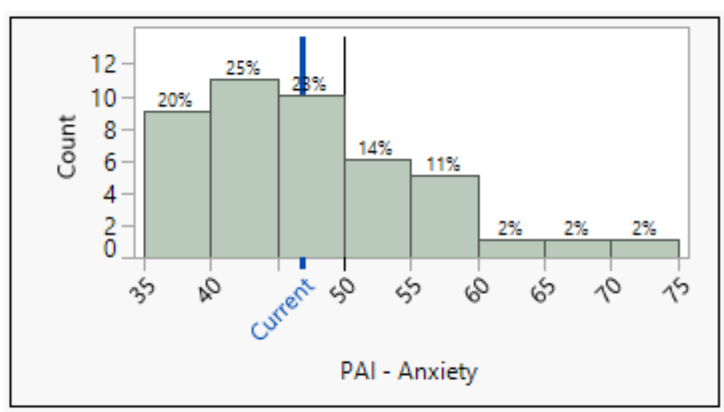

Figure 52. PAI—Anxiety Subscale Score Distribution.

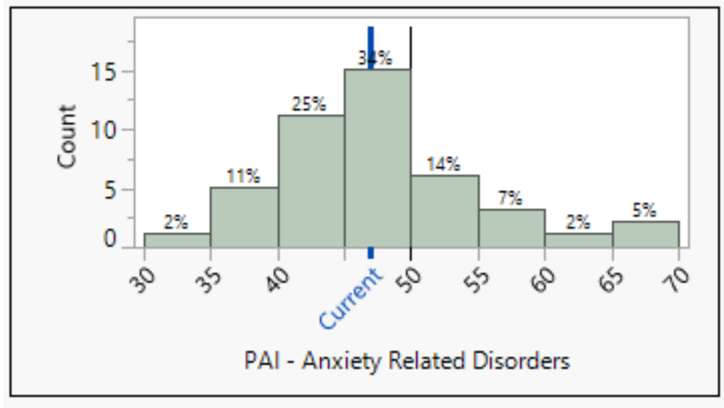

Figure 53. PAI—Anxiety Related Disorders Subscale Score Distribution.

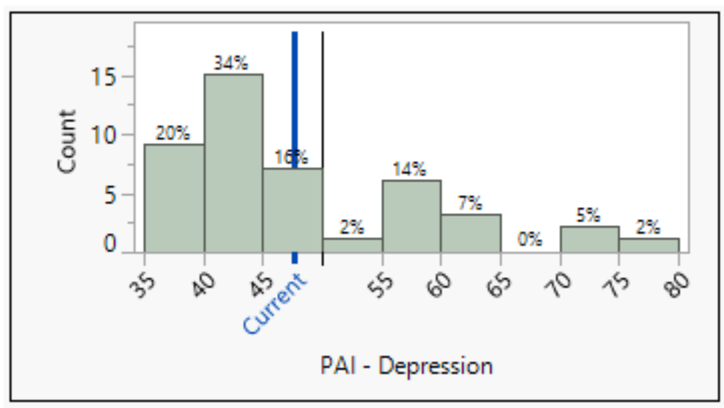

Figure 54. PAI—Depression Subscale Score Distribution.

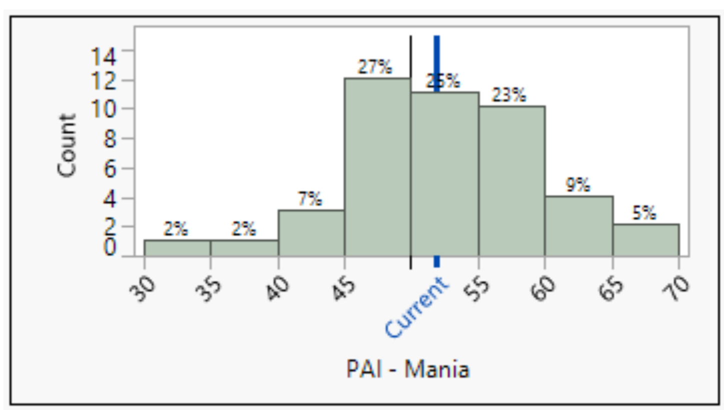

Figure 55. PAI—Mania Subscale Score Distribution.

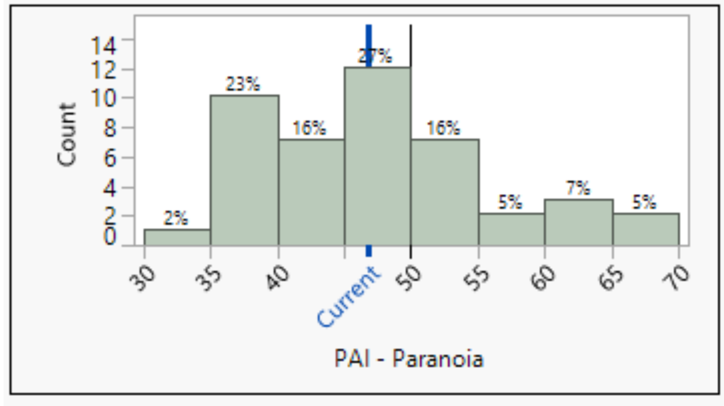

Figure 56. PAI—Paranoia Subscale Score Distribution.

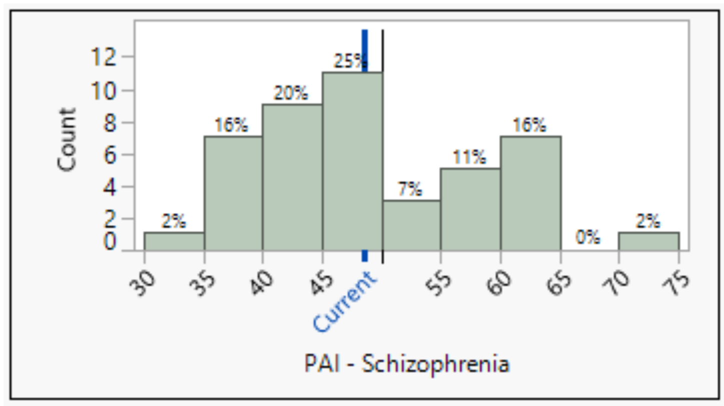

Figure 57. PAI—Schizophrenia Subscale Score Distribution.

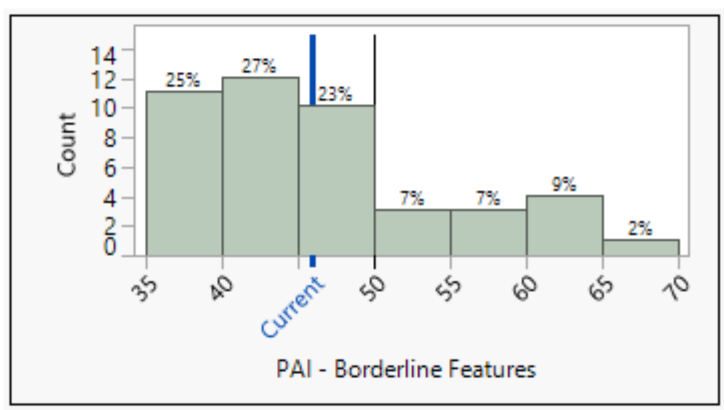

Figure 58. PAI—Borderline Features Subscale Score Distribution.

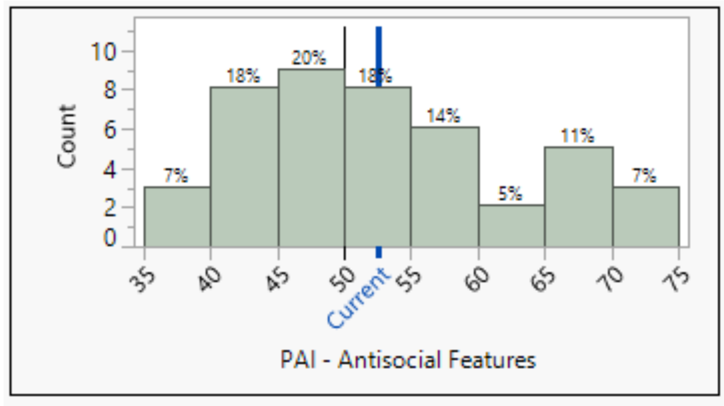

Figure 59. PAI—Antisocial Features Subscale Score Distribution.

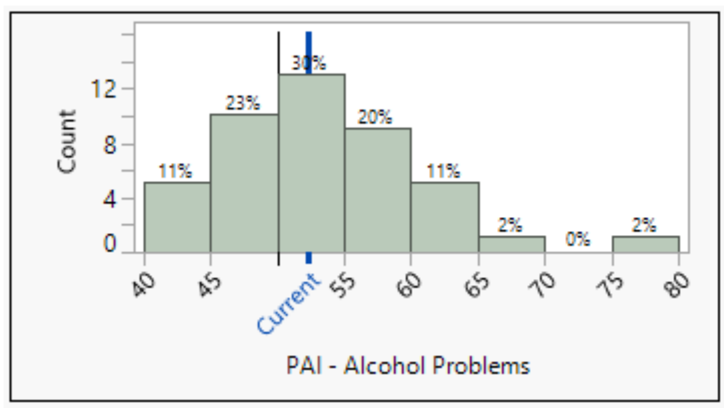

Figure 60. PAI—Alcohol Problems Subscale Score Distribution.

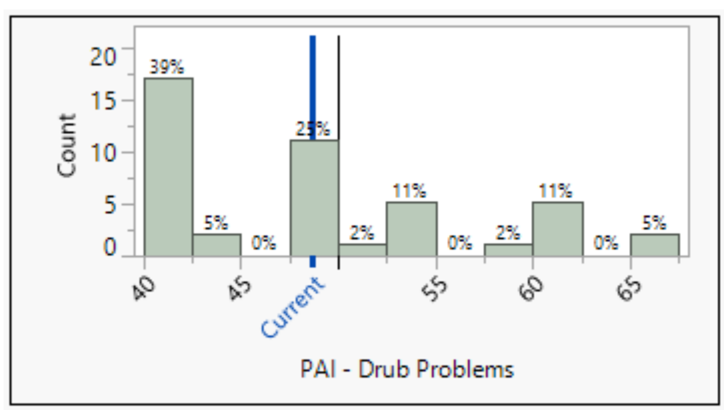

Figure 61. PAI—Drug Problems Subscale Score Distribution.

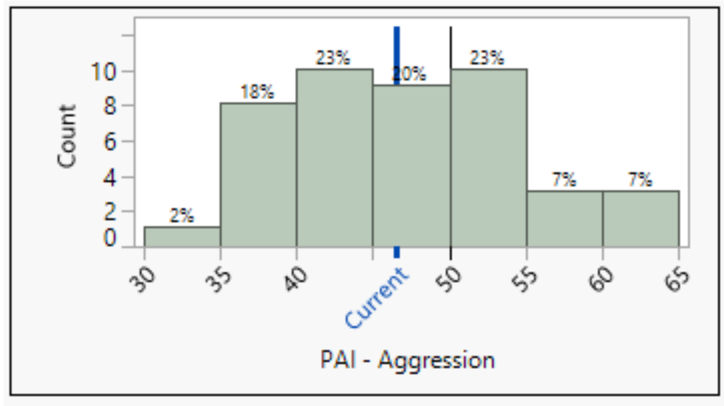

Figure 62. PAI—Aggression Subscale Score Distribution.

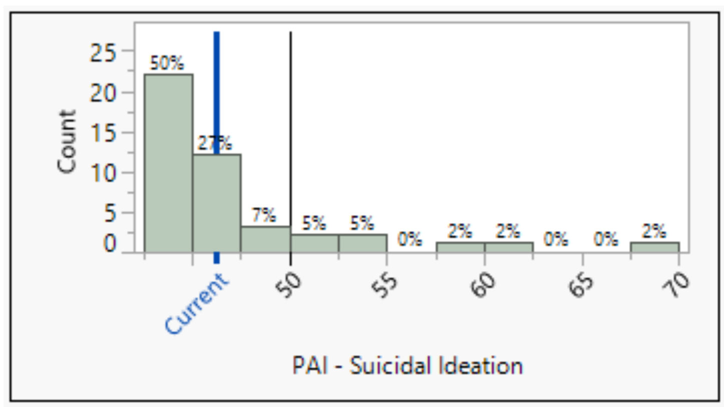

Figure 63. PAI—Suicidal Ideation Subscale Score Distribution.

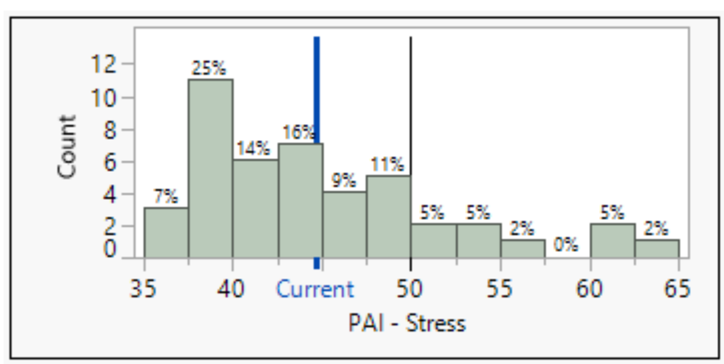

Figure 64. PAI—Stress Subscale Score Distribution.

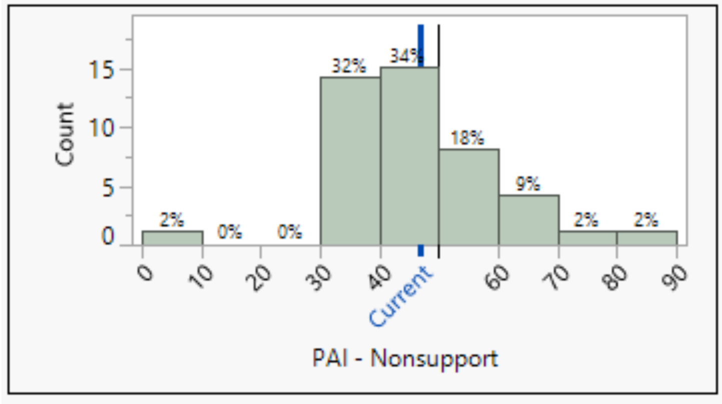

Figure 65. PAI—Nonsupport Subscale Score Distribution.

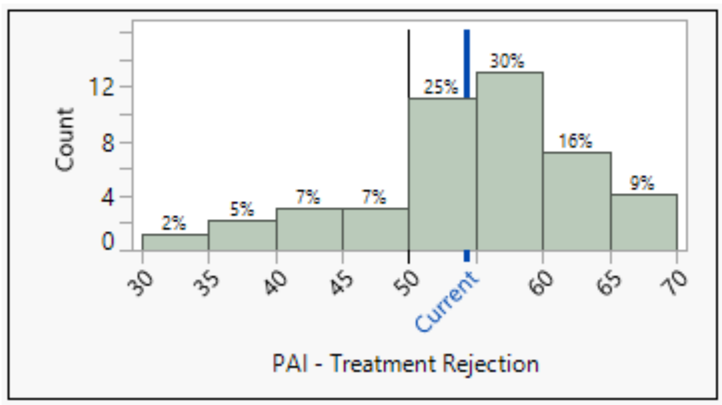

Figure 66. PAI—Treatment Rejection Subscale Score Distribution.

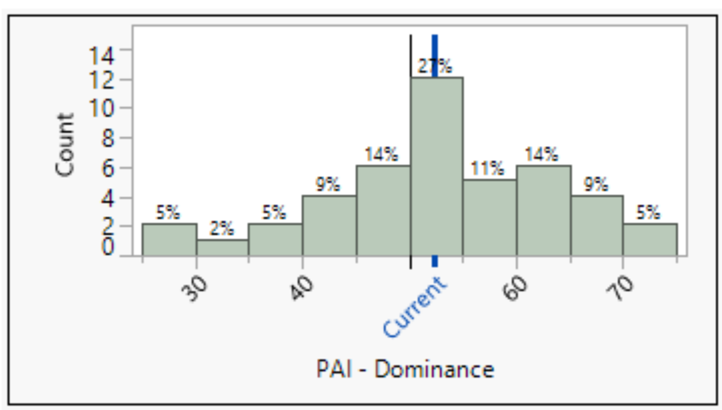

Figure 67. PAI—Dominance Subscale Score Distribution.

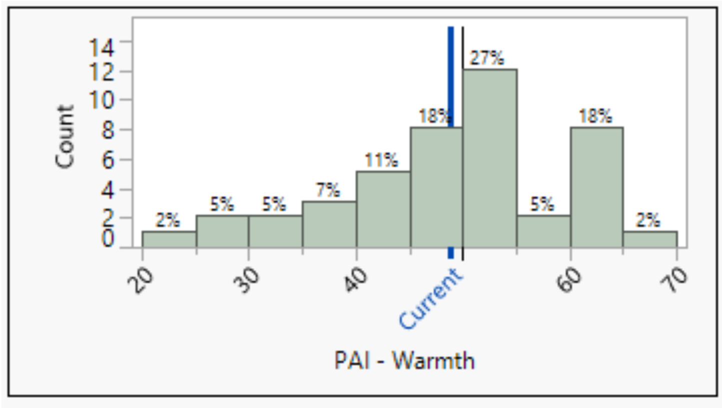

Figure 68. PAI—Warmth Subscale Score Distribution.

14. Positive and Negative Affective Schedule (PANAS)

In terms of the Positive and Negative Affective Schedule (PANAS), the average score in the present study for positive affect (PA) was 32.7 ± 9.9 ranging from 12 to 48, while the average score for negative affect (NA) was 13.5 ± 4.6 ranging from 10 to 29. Both subscales were developed with a higher score indicating better performance, ranging from 10 to 50 (Watson et al., 1988). Compared to the reported mean scores (general timeframe) from Watson et al. (1988) of 35.0 ± 6.4 PA and 18.1 ± 5.9 NA, the participants in this study scored significantly lower on NA. Figures 69 and 70 show the distribution of PA and NA scores, respectively.

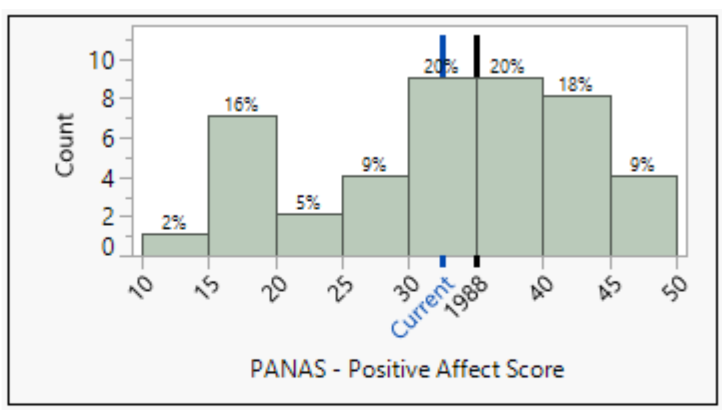

Figure 69. PANAS—Positive Affect Score Distribution.

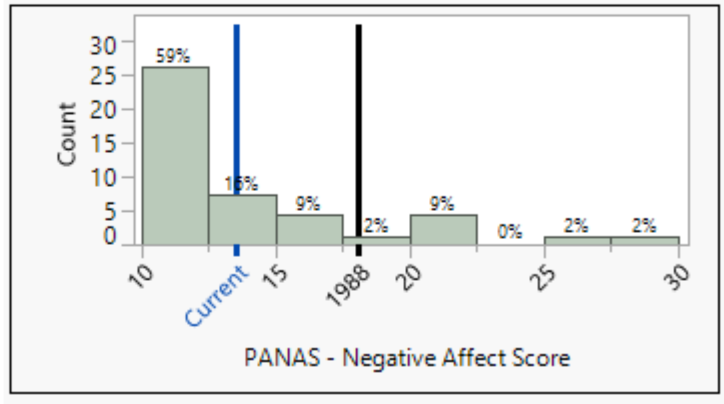

Figure 70. PANAS—Negative Affect Score Distribution.

15. Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5)

The Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5) scale ranges from 0, which is better, to a maximum of 80 (Blevins et al., 2015). The average score in this study on the PCL-5 was 8.6 ± 9.5 ranging from 0 to 33. This score differs from the mean score of 15.42 ± 14.72 that Blevins et al. (2015) reported in their study. Figure 71 shows the PCL-5 score distribution. None of the participants met the criteria for PTSD according to the checklist.

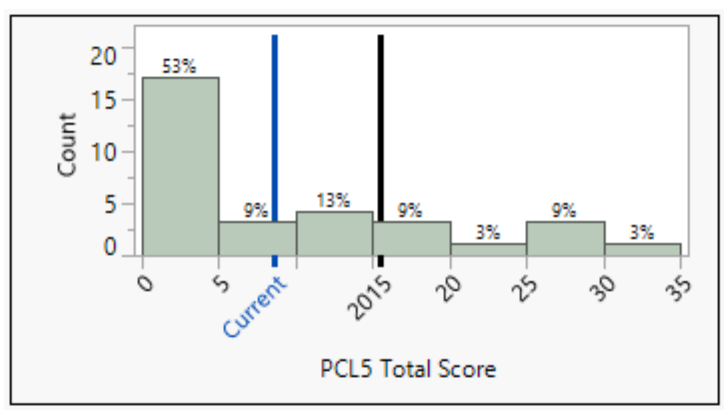

Figure 71. PCL-5 Score Distribution.

16. **Professional Quality of Life Scale (ProQOL-5)**

Each component of the Professional Quality of Life Scale (ProQOL-5) is scored from 10 to 50, with a higher score being better for compassion satisfaction (Stamm, 2010). The opposite holds for burnout and secondary traumatic stress (STS). The average score in this study for compassion satisfaction was 37.1 ± 8.5 ranging from 13 to 50. Burnout and secondary traumatic stress subscales' average score was 18.9 ± 5.0 ranging from 12 to 31 and 15.3 ± 3.8 ranging from 10 to 25, respectively. Figures 72, 74, and 76 show the distribution of scores for the ProQOL, while Figures 73, 75, and 77 display the distribution categorically by level. De La Rosa et al. (2018) aggregated results from 30 studies (N = 5,612), which produced average scores of 37.7 ± 6.5 for compassion satisfaction, 16.7 ± 5.7 for burnout, and 22.8 ± 5.4 for compassion fatigue. Interpreting the reported compassion fatigue score from De La Rosa et al. as actually an STS score, the participants in the present study scored lower on this subscale.

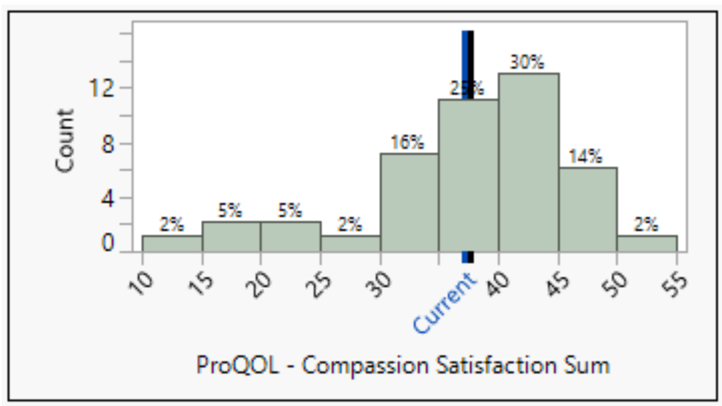

Figure 72. ProQOL—Compassion Satisfaction Score Distribution.

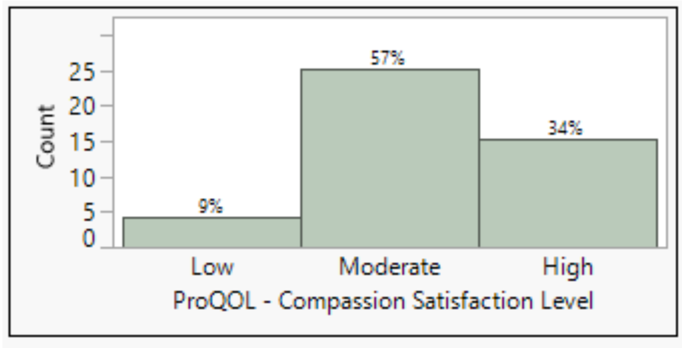

Figure 73. ProQOL—Compassion Satisfaction Level Distribution.

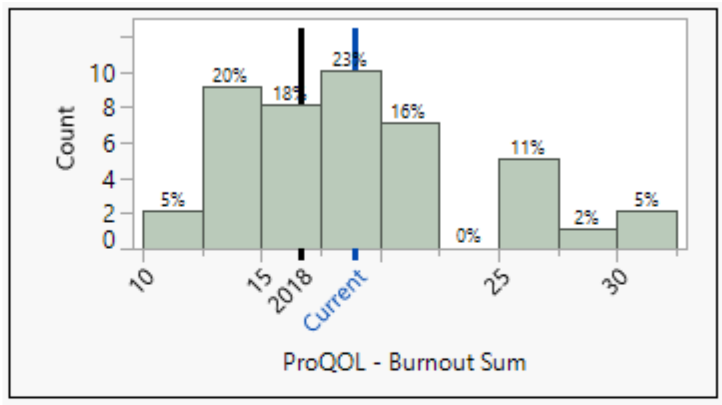

Figure 74. ProQOL—Burnout Score Distribution.

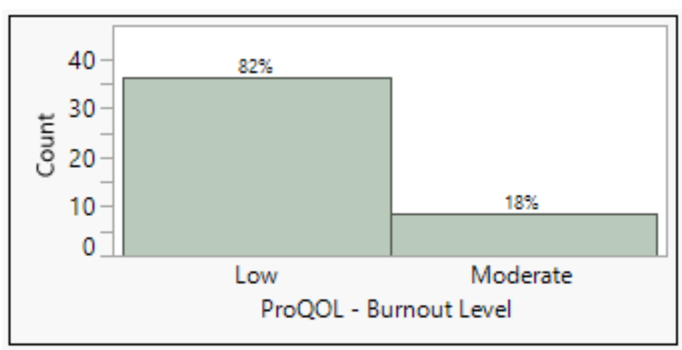

Figure 75. ProQOL—Burnout Level Distribution.

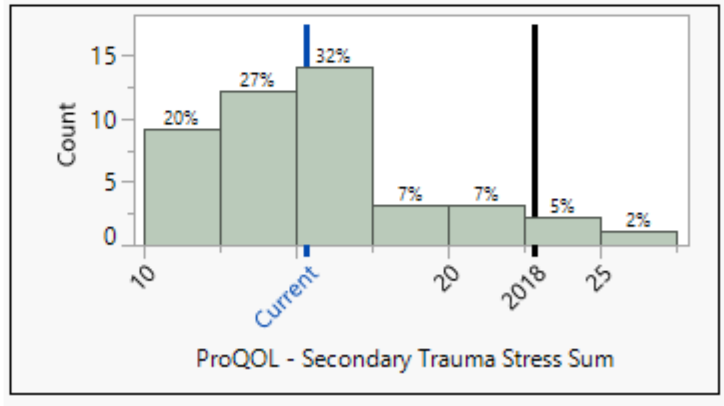

Figure 76. ProQOL—Secondary Traumatic Stress Score Distribution.

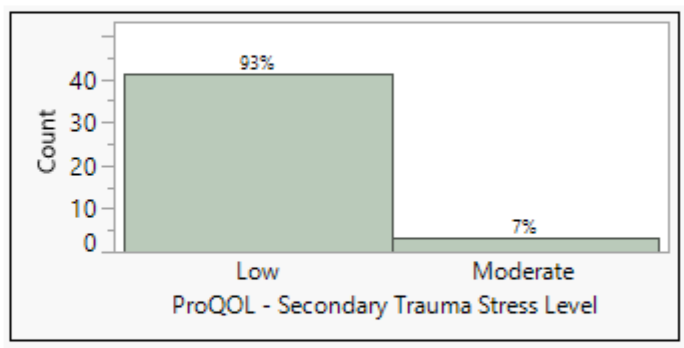

Figure 77. ProQOL—Secondary Traumatic Stress Level Distribution.

17. Psychological Well-Being Scale (PWB)

In terms of the Psychological Well-Being Scale (PWB), each of the subscales is scored on a 7 to 49 point range, where a higher score indicates a better state of well-being (Ryff, 1989). Mean scores from Ryff and Keyes' (1995) nationally representative study of adults compared to the means scores for the current study follow in Table 8. Scores in the current study ranged from 8 to 34 for autonomy, 12 to 35 for environmental mastery, 7 to 23 for personal growth, 7 to 31 for positive relations, 7 to 41 for purpose in life, and 7 to 39 for self-acceptance. Figures 78 through 83 show the present study's distributions for PWB scores. Of note, there is a difference between the autonomy and environmental mastery subscales between Ryff and Keyes and the present study with the study sample scores indicative of better well-being in those two subscales.

Table 8. PWB Comparison

	Ryff and Keyes	Current Study
Measure	**M ± SD**	**M ± SD**
Autonomy	14.6 ± 3.1	20.4 ± 7.4
Environmental mastery	14.9 ± 2.8	20.5 ± 5.9
Personal growth	14.8 ± 3.2	13.5 ± 4.4
Positive relations	14.4 ± 3.2	15.5 ± 6.7
Purpose in life	15.7 ± 2.5	15.6 ± 7.5
Self-acceptance	15.2 ± 2.6	17.7 ± 8.5

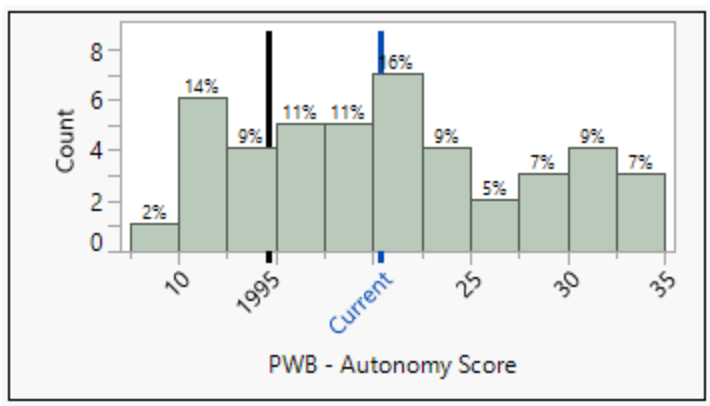

Figure 78. PWB—Autonomy Subscale Score Distribution.

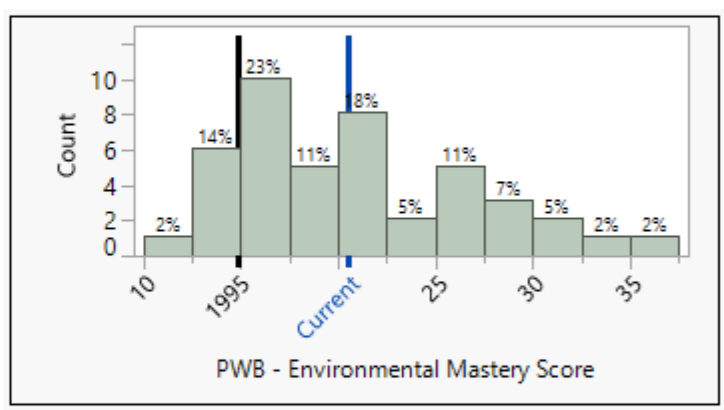

Figure 79. PWB—Environmental Mastery Subscale Score Distribution.

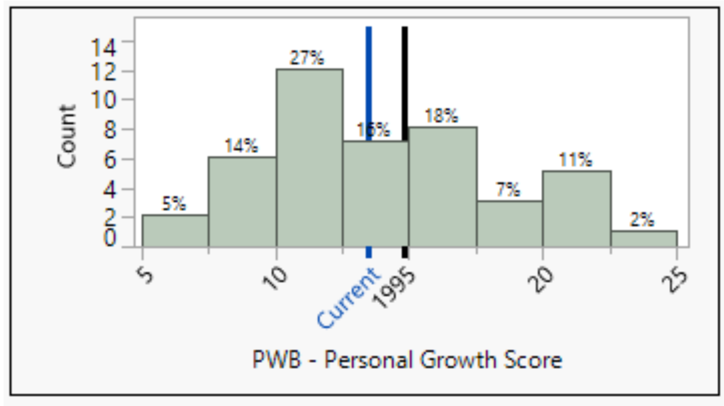

Figure 80. PWB—Personal Growth Subscale Score Distribution.

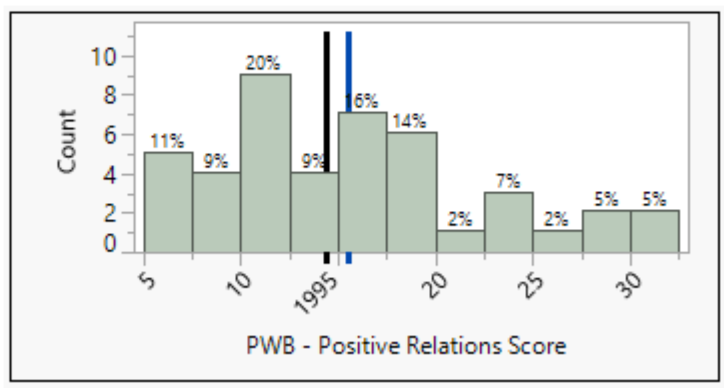

Figure 81. PWB—Positive Relations Subscale Score Distribution.

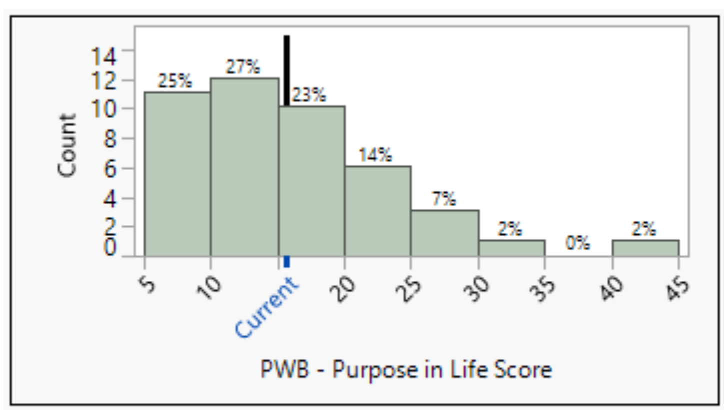

Figure 82. PWB—Purpose in Life Subscale Score Distribution.

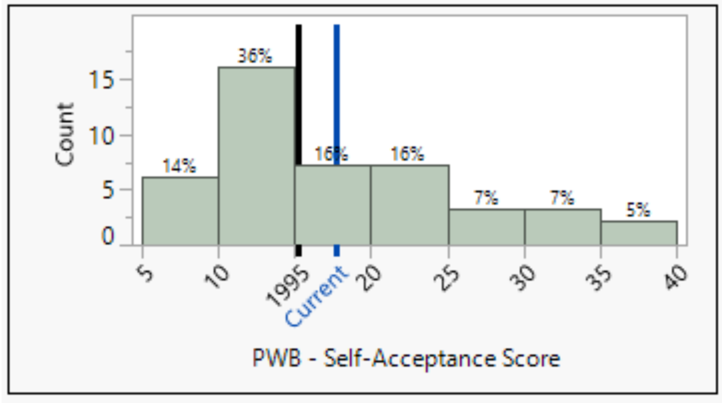

Figure 83. PWB—Self-Acceptance Subscale Score Distribution.

18. Self-Rated Emotional Intelligence Scale (SREIS)

The Self-Rated Emotional Intelligence Scale (SREIS) is built on a 1 to 5 scale, where a higher score indicates more emotional intelligence (Brackett et al., 2006). The average score for this study on the SREIS was 3.6 ± .5, ranging from 2.37 to 4.42, which is consistent with the mean score reported by Bracket et al. (2006) of 3.46 ± 0.41 in their study of 291 undergraduates. Figure 84 shows the distribution of SREIS scores.

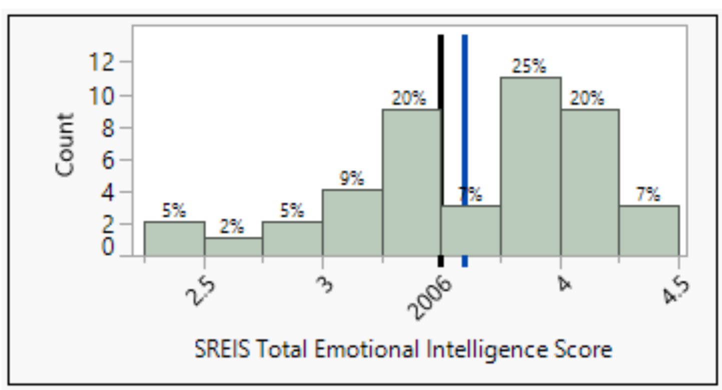

Figure 84. SREIS Score Distribution.

19. State-Trait Anxiety Inventory (STAI)

For the State-Trait Anxiety Inventory (STAI), the current study average scores for state and trait anxiety were 31.6 ± 11.0 and 34.3 ± 9.9, respectively. Scores for state anxiety ranged from 20 to 56, while scores for trait anxiety ranged from 21 to 56. The STAI scale ranges from 20, better, to 80, worse (Spielberger et al., 1970). As reported in *Measuring Health: a Guide to Rating Scales and Questionnaires*, in the 1983 manual, Spielberger reported an average score for working males of 35.7 ± 10.4 for state anxiety and 34.9 ± 9.32 for trait anxiety (Spielberger, 2006). Average scores for females was 35.2 ± 10.6 for state and 34.8 ± 9.2 for trait anxiety. In the current study, the average state and trait scores for males were 30.7 ± 10.5 and 33.5 ± 9.6, and for females were 37.3 ± 13.6 and 40 ± 11.4, respectively. In the current study, males scored significantly lower in both categories than in Spielberger's (1983) study, while females scored higher in both. Figures 85 and 86 show total sample STAI distributions, and Figures 87 through 90 show gender-specific distributions for comparison.

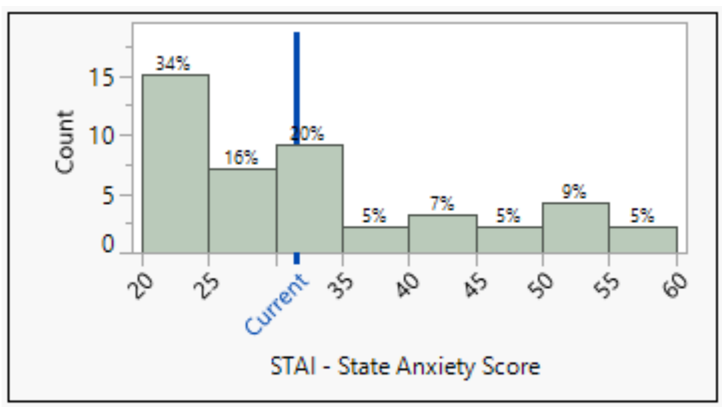

Figure 85. STAI—State Anxiety Sample Score Distribution.

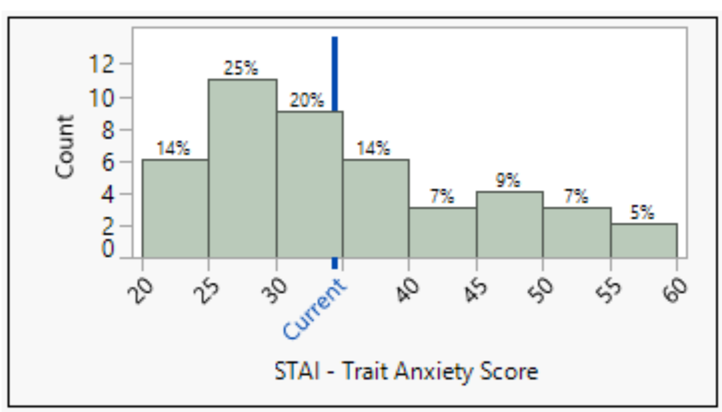

Figure 86. STAI—Trait Anxiety Sample Score Distribution.

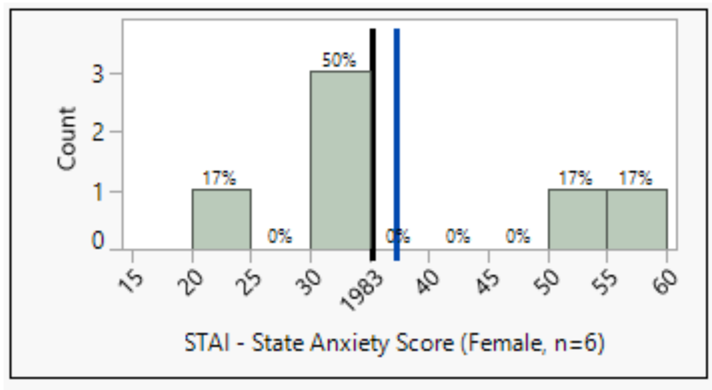

Figure 87. STAI—State Anxiety Score Distribution (Female, n=6).

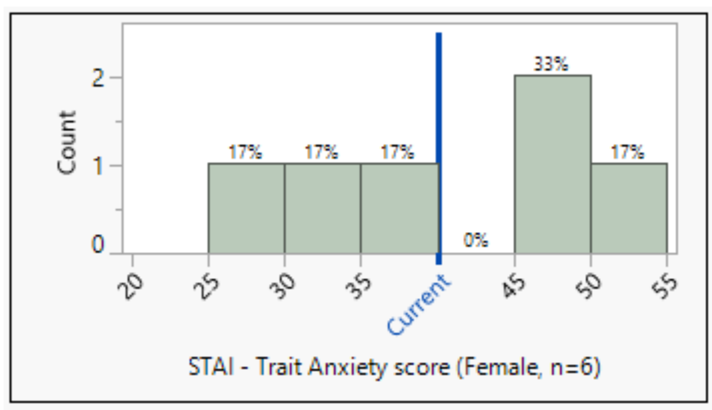

Figure 88. STAI—Trait Anxiety Score Distribution (Female, n=6).

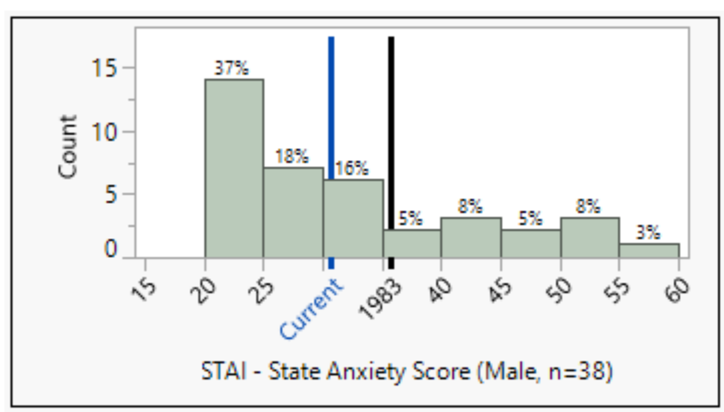

Figure 89. STAI—State Anxiety Score Distribution (male, n=38).

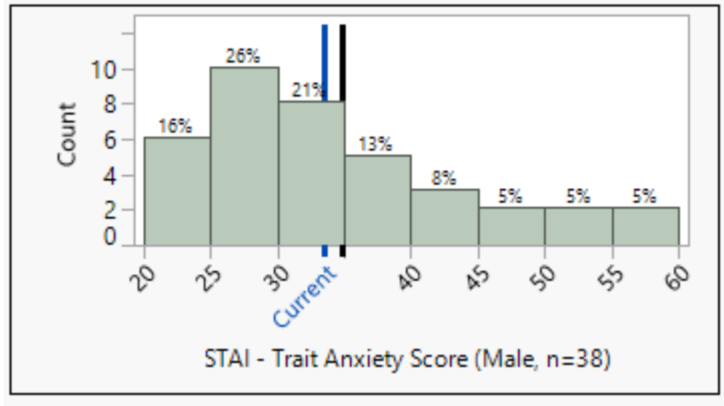

Figure 90. STAI—Trait Anxiety Score Distribution (male, n=38).

20. Satisfaction with Life Scale (SWLS)

A maximum score of 35 indicates better performance on the Satisfaction with Life Scale (SWLS), while a minimum score of 5 indicates the opposite (Diener et al., 1985). The average SWLS score in the current study 27.9 ± 5.9 ranging from 11 to 35, which is slightly higher than the score Diener et al. (1985) reported of 23.5 ± 6.43 in a study of 176 undergraduates. Figure 91 shows the distribution of SWLS scores.

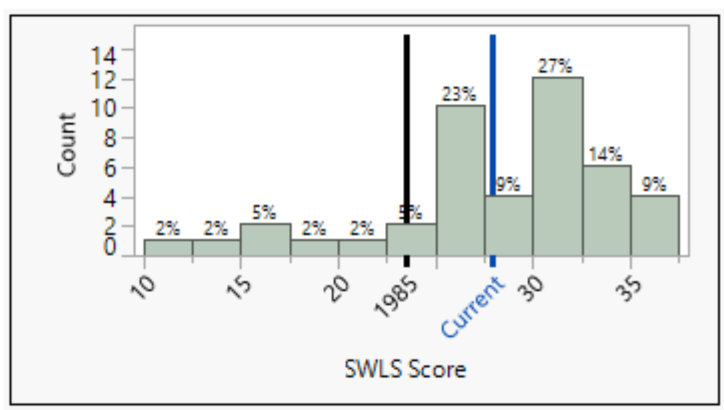

Figure 91. SWLS Score Distribution.

21. UCLA Loneliness Scale

A minimum score of 20 indicates better performance on the UCLA Loneliness Scale, while a maximum score of 80 indicates the reverse (Russell et al., 1978). The average score on the UCLA Loneliness Scale was 35.7 ± 10.9 ranging from 20 to 61. Russell et al. (1978) reported a mean score of 38.9 ± 10.6, ranging from 20 to 76 in a combined sample of 492 participants. Figure 92 shows the distribution of scores for the UCLA Loneliness Scale.

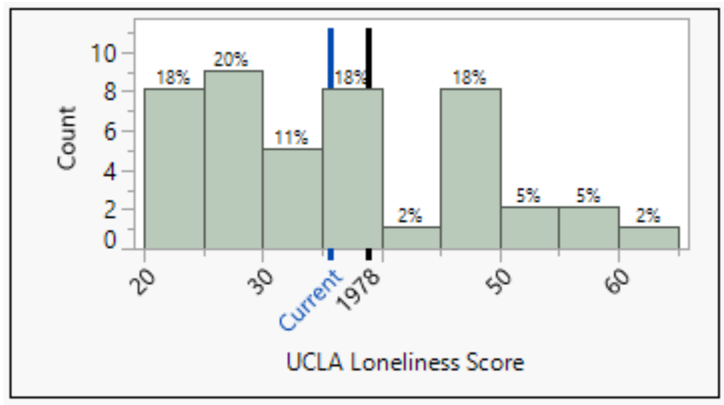

Figure 92. UCLA Loneliness Score Distribution.

C. HEART RATE VARIABILITY

Table 9 displays the result of the grand average nocturnal HRV and average maximum nocturnal HRV for all participants during the baseline period.
Heart rate variability (HRV) metrics during the baseline period.

Table 9. Sample Heart Rate Variability Averages and Ranges.

Metrics	MD (IQR)	Range
Grand average of 5-min HRV during sleep	50.2 (32.2)	25.3 – 161
Average maximum 5-min HRV during sleep	96.1 (46.3)	46.8 – 241

D. ASSOCIATIONS BETWEEN SUBJECTIVE ASSESSMENTS AND HRV METRICS

Next, we used baseline data to assess correlations between the subjective assessments and the two HRV metrics, i.e., average HRV during sleep ($m\text{HRV}_{avg}$) and average maximum HRV during sleep ($m\text{HRV}_{max}$). Table 10 shows the results of this analysis based on Spearman's rho. In general, the expected outcomes were met, whereby, consistent with the literature presented previously, a higher HRV is associated with a healthier individual both physiologically and psychologically. Statistically significant correlations were observed between subjective and objective measures. The following sections will discuss the specific relationships found in these results.

Table 10. Correlations among HRV Metrics and Subjective Assessments. Analysis Based on Spearman's Rho.

Subjective assessments	HRV metrics: Grand mean of HRV during sleep episodes	HRV metrics: Average maximum HRV during sleep episodes
AUDIT	-0.175	-0.216
Beck Depression Inventory (BDI-II)	**-0.384***	**-0.435****
Buss-Perry Aggression Scale (BPAQ) total score	-0.188	-0.196
Physical aggression	-0.064	-0.086
Verbal aggression	-0.041	-0.062
Anger	-0.105	-0.100
Hostility	-0.254	-0.281
Connor-Davidson Resilience Scale (CD-RISC)	0.208	0.184
Difficulties in Emotion Regulation Scale (DERS)	-0.281	-0.247
Flourishing scale	0.116	0.170
Inventory of Interpersonal Problems (IIP-32)		
Total T-score [1]	**-0.320***	-0.250
Domineering/controlling T-score [1]	-0.019	0.078
Vindictive/self-centered T-score [1]	0.049	0.092
Cold/distant T-score [1]	-0.109	-0.071
Socially inhibited T-score [1]	-0.196	-0.156
Nonassertive T-score [1]	-0.250	-0.201
Overly accommodating T-score [1]	-0.295	-0.291
Self-sacrificing T-score [1]	**-0.447****	**-0.363***
Intrusive/needy T-score [1]	**-0.399****	**-0.301***
Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT) overall score	0.206	0.195
Perceiving emotions	0.078	0.018
Using emotions	0.258	0.279
Understanding emotions	0.060	0.052
Managing emotions	0.101	0.120
Multidimensional Scale of Perceived Social Support (MSPSS)		
Family	0.184	0.200
Friends	-0.047	-0.065
Significant other	-0.019	0.038

Subjective assessments	HRV metrics	
	Grand mean of HRV during sleep episodes	Average maximum HRV during sleep episodes
Social support	0.072	0.087
Maslach Burnout Inventory - General Survey (MBI-GS)		
Exhaustion	-0.267	-0.252
Cynicism	-0.238	-0.202
Professional efficacy	0.262	0.283
Patient Stress Questionnaire (PSQ)		
Depression score	-0.280	**-0.341***
Anxiety score	**-0.344***	**-0.399****
Pain score	0.016	-0.020
PTSD score	-0.108	-0.052
Perceived Stress Scale (PSS)	-0.262	-0.258
Personality Assessment Inventory (PAI)		
Inconsistency validity T-score	-0.178	-0.189
Infrequency validity T-score	-0.055	-0.016
Negative impression validity T-score	**-0.313***	**-0.310***
Positive impression validity T-score	-0.257	**0.392****
Somatic concern T-score	-0.300*	**-0.330***
Anxiety T-score	**-0.321***	-0.297
Anxiety related disorders T-score	-0.269	-0.269
Depression T-score	**-0.337***	**-0.387****
Mania T-score	0.031	-0.013
Paranoia T-score	-0.295*	**-0.328***
Schizophrenia T-score	-0.219	-0.267
Borderline features T-score	-0.207	-0.264
Antisocial features T-score	0.027	-0.006
Alcohol problems T-score	-0.137	-0.245
Drug problems T-score	-0.292	-0.269
Aggression T-score	-0.054	-0.053
Suicidal ideation T-score	-0.050	-0.083
Stress T-score	-0.118	-0.226
Nonsupport T-score	-0.049	-0.131
Treatment rejection T-score	0.258	0.266
Dominance T-score	0.223	-0.233
Warmth T-score	0.082	0.118
Positive and Negative Affective Schedule (PANAS)		
Positive affect	0.185	-0.206
Negative affect	**-0.309***	**-0.322***
PTSD Checklist for DSM-5 (PCL-5)	-0.118	-0.046
Professional Quality of Life Scale (ProQOL-5)		
Compassion satisfaction	0.038	0.040
Burnout	**-0.336***	**-0.343***
Secondary traumatic stress	**-0.456****	**-0.440****
Psychological Well-Being Scale (PWB)		
Autonomy	0.290	0.258
Environmental mastery	0.262	**0.321***

Subjective assessments	HRV metrics	
	Grand mean of HRV during sleep episodes	Average maximum HRV during sleep episodes
Personal growth	**0.323***	**0.315***
Positive relations	0.093	0.087
Purpose in life	0.193	0.280
Self – acceptance	**0.313***	**0.340***
Self-Rated Emotional Intelligence Scale (SREIS) total emotional intelligence score	-0.037	-0.076
State-Trait Anxiety Inventory (STAI)		
State anxiety	**-0.343***	**-0.339***
Trait anxiety	**-0.356***	**-0.339***
The Satisfaction with Life Scale (SWLS)	0.049	0.059
UCLA Loneliness score	-0.181	-0.238

Un-adjusted p-values based on Spearman's rho pairwise correlations: "***" $p < 0.001$; "**" $p < 0.01$; "**" $p < 0.050$

Correlation coefficients in bold indicate statistically significant correlations based on the post-hoc BH-FDR procedure

[1] IIP-32 T-scores calculated with sex-specific norms

E. COMPARISON OF POST-TRAINING SCORES WITH BASELINE

A mixed-effects model statistical analysis was used to identify differences in metrics of interest by study phase (baseline, post-training) and treatment group (treatment, control). The interaction term was also included in the model. Results did not provide evidence of differences between the treatment and the control groups. Table 11 displays the comparison and treatment group specific comparison data. Further analysis is needed to extrapolate meaning from the few terms that have statistical relevance. However, a number of confounding factors can influence these outcomes, not the least of which is questionnaire fatigue, given that the participants retook the full battery of assessments.

Table 11. Differences Between Treatment Groups by Assessment Metrics.

Metric	Post-treatment versus baseline (Un-adjusted p-value)	Treatment group (Un-adjusted p-value)	Interaction term	Notes
Alcohol Use Disorders Identification Test (AUDIT) [1]	0.368	0.707	0.422	
Beck Depression Inventory (BDI-II) [1]	0.002	0.147	0.403	Scores decreased in both treatment groups
Buss-Perry Aggression Scale (BPAQ) total score	0.798	0.903	0.224	
Physical aggression	0.586	0.925	0.516	
Verbal aggression	0.979	0.248	0.012	
Anger [1]	0.581	0.718	0.807	
Hostility [1]	0.837	0.099	0.336	
Connor-Davidson Resilience Scale (CD-RISC) [1]	0.564	0.327	0.184	
Difficulties in Emotion Regulation Scale (DERS) [1]	0.159	0.555	0.339	
Flourishing scale [1]	0.529	0.354	0.311	
Inventory of Interpersonal Problems (IIP-32)				
Total T-score [1,3]				
Domineering/controlling T-score [1,3]	0.618	0.157	0.201	
Vindictive/self-centered T-score [1,3]	0.117	0.192	0.253	
Cold/distant T-score [1,3]	0.756	0.822	0.629	
Socially inhibited T-score [1,3]	0.733	0.956	0.678	
Nonassertive T-score [1,3]	0.043	0.354	0.217	Scores decreased in both treatment groups
Overly accommodating T-score [1,3]	0.015	0.705	0.358	Scores decreased in both treatment groups
Self-sacrificing T-score [1,3]	0.186	0.723	0.620	
Intrusive/needy T-score [1,3]	0.371	0.455	0.112	
Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT) overall score	0.215	0.418	0.204	
Perceiving emotions [1]	0.804	0.710	0.470	
Using emotions	0.936	0.637	0.738	
Understanding emotions	0.148	0.157	0.909	
Managing emotions	0.299	0.449	0.102	
Multidimensional Scale of Perceived Social Support (MSPSS)				
Family [1]	0.195	0.420	0.472	
Friends [1]	0.189	0.723	0.427	
Significant other [1]	0.179	0.181	0.322	
Social support [1]	0.719	0.330	0.878	
Maslach Burnout Inventory - General Survey (MBI-GS)				
Exhaustion [1]	0.023	0.437	0.629	Scores decreased in both treatment groups
Cynicism [1]	0.536	0.056	0.242	
Professional efficacy [1]	0.590	0.201	0.013	
Patient Stress Questionnaire (PSQ)				
Depression score [1]	0.238	0.058	0.373	
Anxiety score [1]	0.218	0.065	0.576	

Metric	Post-treatment versus baseline (Un-adjusted p-value)	Treatment group (Un-adjusted p-value)	Interaction term	Notes
Pain score [1]	0.074	0.626	0.264	
PTSD score [1]	0.018	0.843	0.316	Scores decreased in both treatment groups
Personality Assessment Inventory (PAI)				
Inconsistency validity T-score				
Infrequency validity T-score [1,2]	0.536	0.233	0.811	
Negative impression validity T-score [1,2]	0.227	0.862	0.563	
Positive impression validity T-score	0.039	0.128	0.918	Scores increased in both treatment groups
Somatic concern T-score [1]	0.180	0.414	0.135	
Anxiety T-score [1]	0.214	0.197	0.478	
Anxiety related disorders T-score	0.073	0.058	0.235	
Depression T-score [1]	0.321	0.346	0.560	
Mania T-score	0.840	0.941	0.352	
Paranoia T-score	0.859	0.099	0.562	
Schizophrenia T-score	0.017	0.095	0.137	Scores decreased in both treatment groups
Borderline features T-score [1]	0.077	0.101	0.708	
Antisocial features T-score	0.589	0.157	0.663	
Alcohol problems T-score [1]	0.146	0.745	0.153	
Drug problems T-score [1]	0.005	0.992	0.118	Scores decreased in both treatment groups
Aggression T-score	0.412	0.631	0.937	
Suicidal ideation T-score [1]	0.160	0.682	0.572	
Stress T-score [1]	0.980	0.524	0.811	
Nonsupport T-score [1]	0.404	0.092	0.310	
Treatment rejection T-score [1]	0.008	0.182	0.978	Scores increased in both treatment groups
Dominance T-score	0.014	0.318	0.767	Scores increased in both treatment groups
Warmth T-score [1]	0.304	0.730	0.844	
Positive and Negative Affective Schedule (PANAS)				
Positive affect [1]	0.783	0.358	0.950	
Negative affect [1]	0.487	0.756	0.460	
PTSD Checklist for DSM-5 (PCL-5) [1]	0.039	0.566	0.834	Scores decreased in both treatment groups
Professional Quality of Life Scale (ProQOL-5)				
Compassion satisfaction [1]	0.509	0.087	0.019	
Burnout [1]	0.814	0.608	0.810	
Secondary traumatic stress [1]	0.840	0.586	0.702	
Perceived Stress Scale (PSS)	0.673	0.617	0.622	
Psychological Well-Being Scale (PWB)				
Autonomy	0.075	0.590	0.047	
Environmental mastery [1]	0.507	0.322	0.085	
Personal growth	0.087	0.877	0.771	
Positive relations [1]	0.572	0.895	0.064	
Purpose in life [1]	0.354	0.884	0.724	
Self – acceptance [1]	0.608	0.483	0.127	

Metric	Post-treatment versus baseline (Un-adjusted p-value)	Treatment group (Un-adjusted p-value)	Interaction term	Notes
Self-Rated Emotional Intelligence Scale (SREIS) total emotional intelligence score [1]	0.280	0.135	0.013	Evidence of scores changing differently by treatment group, but this change is not statistically significant
State-Trait Anxiety Inventory (STAI)				
State anxiety [1]	0.642	0.498	0.874	
Trait anxiety [1]	0.257	0.438	0.665	
The Satisfaction with Life Scale (SWLS) [1]	0.471	0.092	0.284	
UCLA Loneliness score [1]	0.960	0.689	0.758	
HRV metrics				
Sleep episode grand mean HRV [1]	0.435	0.647	0.587	
Mean of maximum 5-minute HRV [1]	0.306	0.769	0.825	

[1] Square root transformed data

[2] One outlier excluded

[3] IIP-32 T-scores calculated with gender-specific norms

V. DISCUSSION

This study's initial goal was to investigate whether emotional intelligence training could improve resilience as assessed by the subjective assessments of well-being and heart rate variability. The challenges of administering a study remotely and in pandemic conditions were simply too great to execute the research as designed in the time available. Participants completed various amounts of training, with some not completing the training or withdrawing because of the extensive time commitment. Therefore, the research focused on exploring the association between the qualitative and quantitative measures as they relate to each other and to resilience.

A. ASSOCIATIONS BETWEEN HRV METRICS DURING SLEEP AND SUBJECTIVE ASSESSMENTS

It is important to point out the absence of a correlation between scores on the Connor-Davidson Resilience Scale and the qualitative HRV metrics. The CD-RISC is considered to be a highly validated measure of resilience, and this lack of was unexpected. There were, however, several other associations, some anticipated and some unexpected, that emerged from this study.

Specifically, there were significant correlations between nocturnal mean and maximal HRV and anxiety, depression, and compassion fatigue. These correlations have real and consequential implications in assessing resilience. One's ability to adapt and withstand anxious and depressive thoughts is a strong indicator of their ability to cope with and adapt to stressors, both generically and occupationally specific–especially when considering anxiety and depression on opposite ends of the spectrum of autonomic arousal. This connection, and indeed the present data set, require further examination to determine the feasibility and applicability of continued use of wearables in assessing individual and collective resilience. By analyzing psychophysiological measurements on a longitudinal basis, trend analysis is possible and, given the present correlations, indicative of an individual's state of resilience. In turn, this state of resilience, or more importantly the trend as indicated by the easily collected psychophysiological metrics, could potentially provide an early warning for individuals who are at risk of entering, or are currently in, a compromised state of resilience vis-à-vis anxiety, depression, or compassion fatigue. Those connections are discussed explicitly in the following sections.

1. Anxiety

The results identified statistically significant negative correlations between HRV metrics and PSQ anxiety scores ($m\text{HRV}_{avg}$: ρ = -0.344; $m\text{HRV}_{max}$: ρ = -0.399), PAI anxiety ($m\text{HRV}_{avg}$: ρ = -0.321), PAI somatic concern ($m\text{HRV}_{max}$: ρ = -0.330), PAI paranoia ($m\text{HRV}_{max}$: ρ = -0.328), STAI state ($m\text{HRV}_{avg}$: ρ = -0.343; $m\text{HRV}_{max}$: ρ = -0.339) and STAI trait scores ($m\text{HRV}_{avg}$: ρ = -0.356, $m\text{HRV}_{max}$: ρ = -0.339). Somatic concern and paranoia are included in this section due to similar properties of arousal states and distress. The negative relationship between the subscale scores and HRV metrics is consistent with the expectation of a higher cardiac vagal tone, specifically parasympathetic suppression or decreased sympathetic activation, resulting in a generally lower autonomic arousal state. This statistically significant negative correlation across three validated subjective anxiety subscales shows a promising connection for assessing anxiety and arousal regulation via the objective measurement of HRV. Furthermore, the use of nocturnal mean values, both average 5-minute epoch and maximal score, would appear to offer a significant indication of the individual's ability to regulate anxiety longitudinally or more generically in day-to-day life. The use of an ŌURA ring may thereby provide a means to monitor the state of arousal, vis-à-vis anxiety of an individual, and their ability to cope. This coping ability or adaptability is one of the main tenants of most accepted definitions of resilience.

2. Depression

The results identified statistically significant negative correlations between HRV metrics and BDI-II scores ($m\text{HRV}_{avg}$: ρ = -0.384; $m\text{HRV}_{max}$: ρ = -0.435), PSQ depression ($m\text{HRV}_{max}$: ρ = -0.341), and PAI depression scores ($m\text{HRV}_{avg}$: ρ = -0.337; $m\text{HRV}_{max}$: ρ = -0.387). The results suggest that a lower state of depression is associated with a higher mean nocturnal HRV and maximal nocturnal HRV. Like anxiety, this relationship highlights the high cardiac vagal tone within the participants and those experiencing fewer depressive symptoms. This relationship is consistent with the literature concerning HRV, in that it indicates a healthy relationship between the two branches of the autonomic nervous system, as discussed by Vanuk et al. (2019).

3. Compassion Fatigue

Statistically significant negative correlation were identified between the HRV metrics and the two subscales of Compassions Fatigue on the ProQOL-5, i.e., burnout (mHRV$_{avg}$: ρ = -0.336; mHRV$_{max}$: ρ = -0.343) and secondary traumatic stress (mHRV$_{avg}$: ρ = -0.456; mHRV$_{max}$: ρ = -0.440). In both cases, lower scores in burnout and secondary traumatic stress were associated with higher HRV metrics, both nocturnal average and nocturnal maximal. This relationship, too, indicates that the participants have a strong ability to cope with adversity. The subcomponents of compassion fatigue, burnout and secondary traumatic stress, are associated with an individual's hyper-arousal due to the negative aspects of working with others (care providing) (Stamm, 2010). This negative association indicates that individuals with a higher average and maximal nocturnal average are more resilient to the negative stressors associated with their current line of work. For the military population, this is significant. However, it is important to note that the sample population's current working conditions are not typical for a service member. As full-time students, the participants are not currently subjected to what may be considered typical stressors. That being said, it does indicate that the HRV is capable of reflecting the current level of compassion fatigue within an individual, and the conditions and subjective scores make sense with the directional relationship and correlation with HRV.

4. Negative Affect

The results identified statistically significant negative correlations between HRV metrics and PANAS negative affect scores (mHRV$_{avg}$: ρ = -0.309; mHRV$_{max}$: ρ = -0.322). Watson et al. (1988) explain that a low negative affect indicates a "state of calmness and serenity" (p. 1063). Therefore, this negative relationship again indicates the ability of the participants with higher nocturnal average and maximal HRVs to maintain a lower state of autonomic arousal and cope with negative moods (Watson et al., 1988). This finding reinforces the preceding relationships in supporting a state within which the participants with higher HRV values can maintain a more balanced approach to stressors.

5. Psychological Well-Being

The results identified statistically significant negative correlations between HRV metrics and several of the PWB subscales, i.e., environmental mastery ($m\mathrm{HRV}_{max}$: $\rho = -0.321$), personal growth ($m\mathrm{HRV}_{avg}$: $\rho = -0.323$; $m\mathrm{HRV}_{max}$: $\rho = -0.315$), and self-acceptance ($m\mathrm{HRV}_{avg}$: $\rho = -0.313$; $m\mathrm{HRV}_{max}$: $\rho = -0.340$). These associations are consistent with the expected outcome. Ryff and Keyes's (1995) explanation of the subscales of environmental master and self-acceptance indicate that a lower score, which has been correlated in this study with a higher HRV, indicates increased satisfaction and sense of control of one's surrounding and within one's self. Similarly, the authors explain that a low score on the personal satisfaction subscale indicates an individual that seeks growth and adaptation over time, particularly with respect to internal awareness. These attributes are consistent with the literature, which indicates that an increased HRV indicates a better cardiac tone and regulation of the interplay between autonomic systems.

6. Interpersonal Problems

Analysis identified statistically significant correlations between HRV metrics and the IIP-32 subscales of self-sacrificing ($m\mathrm{HRV}_{avg}$: $\rho = -0.443$; $m\mathrm{HRV}_{max}$: $\rho = -0.359$) and intrusive/needy ($m\mathrm{HRV}_{avg}$: $\rho = -0.422$; $m\mathrm{HRV}_{max}$: $\rho = -0.319$) as well as the total score ($m\mathrm{HRV}_{avg}$: $\rho = -0.320$). These associations between these subjective and objective measurements is unexpected, as the characteristics matching a low score on the subscales have little connectivity with cardiac vagal tone. A low score on these subscales indicates that the individual is internally focused and less likely to become overly involved in others' lives (Mind Garden, n.d.). Given the literature review, if any relationship was to be found, the expectation would be a negative relationship with the subscales of domineering/controlling, vindictive/self-centered, socially inhibited, and due to the EI-like properties, cold/distant (Mind Garden, n.d.). Such a relationship would indicate an individual's ability to adapt, relax, and is less aggressive. The negative relationship with the total IIP-32 score does is reasonable and indicates that a higher HRV is associated with less interpersonal problems, a more balanced personality, and less distress (Mind Garden, n.d.).

7. PAI Validity Subscales

The presence of a negative correlation between the validity subscale of negative impression ($m\text{HRV}_{avg}$: $\rho = -0.313$; $m\text{HRV}_{max}$: $\rho = -0.310$) and a positive correlation with the positive impression validity subscale ($m\text{HRV}_{max}$: $\rho = 0.392$) is not considered relevant. The subscales are designed to indicate to the assessor if the assessment presents a more negative or more positive picture of the participant (Morey & Ambwani, 2008).

B. MEASURING RESILIENCE

The aim of quantifiably measuring resilience was, to say the least, a lofty goal. The discovery of such a metric is undoubtedly beyond the capabilities posed within this study. However, the associations established within the study's scope are a clear advancement in the realm of connecting the complicated regulatory process that is resiliency and adds to the growing body of research surrounding heart rate variability. Furthermore, this study has added to the value of utilizing wearables to monitor and assess individuals in the non-clinical environment known as *daily life*. Devices such as the ŌURA ring present an unprecedented opportunity for data collection, which, when paired with the growing capabilities of machine learning and artificial intelligence (outside the scope of the current study), could prove to be exceptionally insightful. In particular, the output from such devices could be instrumental in developing a more complete understanding of the human body's stress coping systems' internal mechanisms and interactions.

C. STUDY LIMITATIONS

This study had several limitations. Collaboration between the two institutions, the University of Arizona and the Naval Postgraduate School, proved significantly more difficult than initially anticipated, which was only further complicated by the pandemic considerations at each institution.

Most significantly, this study was limited by time. A lengthy approval process involving both universities delayed the study's start, which resulted in an abbreviated data collection and, more importantly, a severely shortened data analysis phase. The plethora of data collected over nearly 100 days of near-continuous physiological monitoring on 44 service members through a pandemic offers a multitude of follow-on research opportunities.

The use of the ŌURA ring, a relatively new piece of equipment, presented additional challenges when providing information and assurances regarding the protection of personally identifiable information. Furthermore, the ŌURA ring is designed to give feedback to the user meant to improve their lifestyle. This feedback considers the primary variables of HR and HRV when making recommendations and reporting the calculated scores to the individual. The recommendations, feedback, and knowledge that they were participating in a study (aka the "Hawthorne effect") could have resulted in the participants making behavioral changes, thus impacting the data.

Currently, the ŌURA ring is only offered in whole ring sizes from U.S. size 6 to 13. There were instances when participants were sized for the best fit for a preferred finger instead of the best fit. In this manner, sizing was meant to increase the chances of a participant wearing the ring without discomfort and providing the most longitudinal data. Participants were told that swapping fingers and hands was allowed but asked to notify the research team of such a decision. Despite this, and due to other factors, there were several nights where participants' data was not collected. Two participants lost rings, and another broke a ring resulting in multiple nights of lost data from individuals. Because the ring is worn on an extremity, there are also instances where large portions of data are missing from individual sleep periods. This data loss usually occurs due to poor or lost circulation, which then impacts the PPG's ability to detect IBI. Moreover, fingers are subject to swelling and shrinking for various reasons, which can degrade PPG accuracy or cause the wearer to remove the ring or switch fingers or hands.

Initially, the study intended to recruit up to 200 participants meeting the qualifications of an active duty, U.S. military service member, Naval Postgraduate student. As an incentive to participate in the study and compensate for their time, the study description initially indicated that participants could keep the ŌURA ring. This compensation was ultimately deemed impermissible by the NPS Legal Office and Institutional Review Board. As a result, the sample size (N = 44) was well below the desired recruitment goal.

Within the recruited sample, participants were largely male officers, with a small representation of female officers, and only one male warrant officer and one male enlisted member. All members are considered senior within the context of military service. Forty percent of the participants come from a special operations background, which is not representative of the Joint Force. Further, 38% of the participants came from a single department, which is not representative of the Naval Postgraduate Population. Therefore, drawing population comparisons from this sample set is not appropriate.

The study conditions were designed to admit several confounding factors because it was conducted in real-time as part of the participants' daily lives. However, during the study, participants' normal patterns of life were significantly disrupted due to COVID-19 restrictions (social support, travel, face mask wear, access to physical fitness equipment, teleworking, etc.). Furthermore, two large wildfires surrounded the area where most of the participants lived, likely affecting HR and HRV readings. Conducting the study outside of a laboratory where in-person interactions were restricted and discouraged certainly impacted the NPS research team's ability to monitor the participants and ensure or encourage active participation and task completion.

For various reasons outside the research team's control, the termination date was accelerated, resulting in varying lengths of data collection for the participants. Variations in the collection period also occurred due to rings being issued by appointment on any weekday, while assessments were only initiated on Mondays. The resulting discrepancy meant that some participants wore the ring for four weeks before taking assessments, while others wore the ring for only two weeks before the assessments. When considering the ŌURA ring's purpose and its potential to change behavior, this variation may have impacted assessment and measurement results.

It would be a tremendous understatement to conclude that all relationships have been fully explored within the scope of this study. For this thesis, only one of the metrics collected by the ŌURA ring, HRV, was analyzed. The data set, including raw inter-beat-intervals and temperature deviations among numerous other metrics, both algorithm-based and raw (see Table 1), has largely been untouched due to time constraints.

When considering the study was executed with typically only two in-person interactions, there was no way to ensure that the enrolled participant completed each of the assigned assessments or wore the ŌURA ring for data collection. Although unlikely, it is possible that a person outside of the study took assessments or wore the ŌURA ring for data collection.

Stress management practices such as mindfulness, mediation, and breathing were introduced in the "treatment" group's Emotional Intelligence Training. However, the possibility exists that both groups' members were already employing these strategies, or members of the control group began practicing these strategies on their own during the study. A post-study questionnaire was developed to identify which of the participants were actively using stress management techniques and the frequency of use; however, the collection of this data fell outside the timeline for this thesis.

D. CONCLUSION

Ultimately, the utility of the ŌURA ring and similar wearable devices is not to offer a clinical evaluation of an individual or a group. Rather, its utility lies in its ability to provide the wearer with information regarding physiological processes and the quality of these processes. In doing so, the wearable arms the user with easily digestible, individualized feedback that can be connected to lifestyle choices. Wearables with precision sensors, such as the ŌURA ring, provide a low-cost data collection tool that facilitates rapid, real-time, and reliable analysis. When used in conjunction with guidance from medical professionals, these wearables offer a means to develop a holistic approach to health, and more specifically, resilience. The concept is to provide early warning and identify trends through longitudinal and qualitative data that is the basis for a conversation about health and resilience between the wearer and a qualified medical professional. Wearables such as the ŌURA ring offer the user the ability to identify when stress is having adverse effects on the body, adaptation is not taking place, and resilience is compromised. These wearables also offer a unique opportunity for wearers to safely experiment with well-established, researched, and documented lifestyle changes to view effects on physiological metrics. When pairing these personalized individual observations with regular healthcare screenings and discussions with care providers, the opportunities to optimize one's health and resilience are truly limitless.

THIS PAGE INTENTIONALLY LEFT BLANK

VI. RECOMMENDATIONS

The first recommendation is to continue the exploration of longitudinal physiological data collection. Given the proven accuracy of the ŌURA ring's PPG sensor and the promising performance of its sleep algorithms, this device offers rare opportunities to track and evaluate large cohorts across extensive periods. Perhaps an ideal experiment would focus on a cohort, or appropriate representation, of Naval Postgraduate School students from arrival to departure. NPS offers a unique environment to observe active duty service members in a relatively controlled environment. Furthermore, the current data set offers immediate opportunities for continued data analysis.

Second, it is recommended that the military follow civilian organizations' lead and institute more pervasive use of wearables. The ŌURA ring is currently being employed in various studies to monitor participants' health and attempt to screen for COVID-19 symptoms. A variety of research questions can be pursued, given an appropriate amount of time. Several organizations have begun collaborating with a wearable to monitor the health and readiness of their members. In the newly published Field Manual 7-22 Holistic Health and Fitness, the Army has refocused its efforts on understanding readiness. The manual identifies readiness in five domains: physical, nutritional, mental, spiritual, and sleep. A wearable device such as the ŌURA ring can capture, augment, or enhance three of those domains (physical, sleep, and spiritual through the "Take a moment" feature).

Third, a modernization of the storage and collection of data is needed within NPS's review process. Industry standards for safety and privacy, especially within wearable and cloud-based services, has become exceptionally stringent. For example, in this study, linking participants' accounts with Apple Health and Google Fit would have added to the collection of data available for analysis that impacted HR and HRV, such as exercise. Accepting and employing more of such services decreases the chance of data loss, increases collection and analysis capability, and can lead to a better understanding of participants holistically.

Lastly, the rules for compensating military members for their time need to be reviewed and modernized. The determination not to allow participants to keep the ŌURA ring at the conclusion of the study is believed to have severely degraded recruitment. Participants were asked to volunteer, at a minimum, 67 days of data, without any compensation. This research's scope and breadth fell well outside the accepted duty day or the commonly expected execution of duty as a service member. In comparison, the University of Arizona's review required adequate compensation ($400) for those participants who completed the study and a pro-rated compensation for those who failed to complete or withdrew from the study.

APPENDIX. END-OF-STUDY QUESTIONNAIRE

End-of-study Questionnaire

Instructions: *Please answer ALL questions as accurately as possible. ALL information is confidential and will be used only for research purposes.*

1. In the last three months, have you practiced any of the following methods of relaxation breathing? If so, how often. Check ALL that apply ☑ and indicate frequency (for example: 4 times per day)

☐	Diaphragmatic breathing	How often? ____________________
☐	Yogic breathing	How often? ____________________
☐	Alternate nostril breathing	How often? ____________________
☐	Other methods of relaxation breathing (please specify): ________________________	How often? ____________________

2. In the last three months, have you practiced any of the following methods? If so, how often. Check ALL that apply ☑ and indicate frequency (for example: 4 times per day)

☐	Progressive muscle relaxation	How often? ____________________
☐	Guided visualization or meditation	How often? ____________________
☐	Cognitive restructuring or reframing to overcome negative thoughts	How often? ____________________
☐	Journaling	How often? ____________________
☐	Mindful moments	How often? ____________________

3. In the last three months, what other stress reduction techniques have you used?

____
____
____

4. Please add other comments here:

____
____
____

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF REFERENCES

Alkozei, A., Smith, R., Demers, L. A., Weber, M., Berryhill, S. M., & Killgore, W. D. S. (2019). Increases in emotional intelligence after an online training program are associated with better decision-making on the Iowa Gambling Task. *Psychological Reports*, *122*(3), 853–879. https://doi.org/10.1177/0033294118771705

Aurelius, M. (1984). *Meditations: A new translation, with an introduction, by Gregory Hays.* (G. Hays, Trans.). Modern Library.

Beck, A. T., Steer, R. A., & Brown, G. (1996). Beck depression inventory–II. *Psychological Assessment*.

Bernston, G. G., J. Thomas Bigger Jr., Dwain L. Eckberg, Paul Grossman, Peter G. Kaufmann, Malik, M., Nagaraja, K. N., Porges, S. W., Saul, J. P., Stone, P. H., & Van Der Molen, M. W. (1997). Heart rate variability: Origins, methods, and interpretive caveats. *Psychophysiology*, *34*(6), 623–648. https://doi.org/10.1111/j.1469-8986.1997.tb02140.x

Blevins, C. A., Weathers, F. W., Davis, M. T., Witte, T. K., & Domino, J. L. (2015). The posttraumatic stress disorder checklist for DSM-5 (PCL-5): Development and initial psychometric evaluation. *Journal of Traumatic Stress*, *28*(6), 489–498.

Brackett, M. A., Rivers, S. E., Shiffman, S., Lerner, N., & Salovey, P. (2006). Relating emotional abilities to social functioning: A comparison of self-report and performance measures of emotional intelligence. *Journal of Personality and Social Psychology*, *91*(4), 780.

Buss, A. H., & Perry, M. (1992). The aggression questionnaire. *Journal of Personality and Social Psychology*, *63*(3), 452.

Chaplain Corps. (n.d.). U.S. Army. Retrieved March 9, 2020, from https://www.army.mil/chaplaincorps

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior*, 385–396.

Connor, K. M., & Davidson, J. R. T. (2003). Development of a new resilience scale: The Connor-Davidson Resilience Scale (CD-RISC). *Depression and Anxiety*, *18*(2), 76–82. https://doi.org/10.1002/da.10113

Coutu, D. (2002). How Resilience Works. *Harvard Business Review*, *80*, 46–50, 52, 55 passim.

Crombie, D., Lombard, C., & Noakes, T. (2009). Emotional Intelligence Scores Predict Team Sports Performance in a National Cricket Competition. *International Journal of Sports Science & Coaching*, *4*(2), 209–224. https://doi.org/10.1260/174795409788549544

Cull, J. G., & Gill, W. S. (1989). Suicide probability scale (SPS). *Los Angeles: Western Psychological Services*.

de Zambotti, M., Rosas, L., Colrain, I. M., & Baker, F. C. (2019). The Sleep of the Ring: Comparison of the ŌURA Sleep Tracker Against Polysomnography. *Behavioral Sleep Medicine*, *17*(2), 124–136. https://doi.org/10.1080/15402002.2017.1300587

Diener, Ed, Emmons, R. A., Larsen, R. J., & Griffin, S. (1985). The satisfaction with life scale. *Journal of Personality Assessment*, *49*(1), 71–75.

Diener, Ed, Wirtz, D., Tov, W., Kim-Prieto, C., Choi, D., Oishi, S., & Biswas-Diener, R. (2010). New Well-being Measures: Short Scales to Assess Flourishing and Positive and Negative Feelings. *Social Indicators Research*, *97*(2), 143–156. https://doi.org/10.1007/s11205-009-9493-y

Folke, C., Carpenter, S. R., Walker, B., Scheffer, M., Chapin, T., & Rockström, J. (2010). Resilience Thinking: Integrating Resilience, Adaptability and Transformability. *Ecology and Society*, *15*(4), art20. https://doi.org/10.5751/ES-03610-150420

Gratz, K. L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the difficulties in emotion regulation scale. *Journal of Psychopathology and Behavioral Assessment*, *26*(1), 41–54.

Hancock, P. A., & Szalma, J. L. (Eds.). (2008). *Performance under stress*. Ashgate Pub.

Horowitz, L., Alden, L., Wiggins, J., & Pincus, A. (2000). *Inventory of interpersonal problems*. The Psychological Corporation.

Hourani, L. L., Davila, M. I., Morgan, J., Meleth, S., Ramirez, D., Lewis, G., Kizakevich, P. N., Eckhoff, R., Morgan, T., Strange, L., Lane, M., Weimer, B., & Lewis, A. (2020). Mental health, stress, and resilience correlates of heart rate variability among military reservists, guardsmen, and first responders. *Physiology & Behavior*, *214*, 112734. https://doi.org/10.1016/j.physbeh.2019.112734

How Oura Determines Your Personal Recovery, Sleep, and Activity Scores. (n.d.). Oura Help. Retrieved September 8, 2020, from http://support.ouraring.com/hc/en-us/articles/360039415753

Kinnunen, H. (2016). *Sleep Lab validation of a wellness ring in detecting sleep patterns based on photoplethysmogram, actigraphy and body temperature*. 6.

Kinnunen, H., & Koskimäki, H. (2018). *The HRV of the Ring – Comparison of nocturnal HR and HRV between the ŌURA ring and ECG*. 8.

Kinnunen, H., Rantanen, A., Kenttä, T., & Koskimäki, H. (2020). Feasible assessment of recovery and cardiovascular health: Accuracy of nocturnal HR and HRV assessed via ring PPG in comparison to medical grade ECG. *Physiological Measurement*, *41*(4), 04NT01. https://doi.org/10.1088/1361-6579/ab840a

Kiviniemi, A. M., Hautala, A. J., Kinnunen, H., & Tulppo, M. P. (2007). Endurance training guided individually by daily heart rate variability measurements. *European Journal of Applied Physiology*, *101*(6), 743–751. https://doi.org/10.1007/s00421-007-0552-2

Kroenke, K., Spitzer, R. L., & Williams, J. B. W. (2001). The PHQ-9: Validity of a brief depression severity measure. *Journal of General Internal Medicine*, *16*(9), 606–613. https://doi.org/10.1046/j.1525-1497.2001.016009606.x

Krueger, G. (2008). Contemporary and future battlefields: Soldier stresses and performance. *Performance Under Stress*, 19–44.

Laborde, S., Brüll, A., Weber, J., & Anders, L. S. (2011). Trait emotional intelligence in sports: A protective role against stress through heart rate variability? *Personality and Individual Differences*, *51*(1), 23–27. https://doi.org/10.1016/j.paid.2011.03.003

Levinson, D. B., Stoll, E. L., Kindy, S. D., Merry, H. L., & Davidson, R. J. (2014). A mind you can count on: Validating breath counting as a behavioral measure of mindfulness. *Frontiers in Psychology*, *5*. https://doi.org/10.3389/fpsyg.2014.01202

Maslach, C., Jackson, S. E., Leiter, M. P., Schaufeli, W. B., & Schwab, R. L. (1986). *Maslach burnout inventory* (Vol. 21). Consulting psychologists press Palo Alto, CA.

Mayer, J. D., Salovey, P., & Caruso, D. R. (2002). *Mayer-Salovey-Caruso emotional intelligence test (MSCEIT) item booklet*.

Meredith, L. S., United States, & Rand Corporation (Eds.). (2011). *Promoting psychological resilience in the U.S. military*. Rand Corporation.

Morey, L.C. (1991). *The Personality Assessment Inventory Professional Manual*. Psychological Assessment Resources.

Morey, L.C. (2007). *The Personality Assessment Inventory Professional Manual (2nd edn)* (2nd ed.). Psychological Assessment Resources.

Multi-health-systems-usd. (n.d.). Retrieved September 9, 2020, from https://storefront.mhs.com/collections/msceit

Prins, A., Ouimette, P., Kimerling, R., Camerond, R. P., Hugelshofer, D. S., Shaw-Hegwer, J., Thrailkill, A., Gusman, F. D., & Sheikh, J. I. (2004). The primary care PTSD screen (PC–PTSD): Development and operating characteristics. *Primary Care Psychiatry*, *9*(1), 9–14. https://doi.org/10.1185/135525703125002360

Richardson, G. E. (2002). The metatheory of resilience and resiliency. *Journal of Clinical Psychology*, *58*(3), 307–321. https://doi.org/10.1002/jclp.10020

Russell, D., Peplau, L. A., & Ferguson, M. L. (1978). Developing a measure of loneliness. *Journal of Personality Assessment*, *42*(3), 290–294.

Ryff, C. D. (1989). Happiness is everything, or is it? Explorations on the meaning of psychological well-being. *Journal of Personality and Social Psychology*, *57*(6), 1069.

Saunders, J. B., Aasland, O. G., Babor, T. F., De La Fuente, J. R., & Grant, M. (1993). Development of the Alcohol Use Disorders Identification Test (AUDIT): WHO Collaborative Project on Early Detection of Persons with Harmful Alcohol Consumption-II. *Addiction*, *88*(6), 791–804. https://doi.org/10.1111/j.1360-0443.1993.tb02093.x

Selye, H. (1976). *Stress in health and disease*. Butterworths.

Silverman, M. N., & Deuster, P. A. (2014). Biological mechanisms underlying the role of physical fitness in health and resilience. *Interface Focus*, *4*(5), 20140040. https://doi.org/10.1098/rsfs.2014.0040

Smith, R., Killgore, W. D. S., Alkozei, A., & Lane, R. D. (2018). A neuro-cognitive process model of emotional intelligence. *Biological Psychology*, *139*, 131–151. https://doi.org/10.1016/j.biopsycho.2018.10.012

Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. (1970). *STAI Manual for the State-Trait Anxiety Inventory*. Consulting Psychologists Press.

Spitzer, R. L., Kroenke, K., Williams, J. B. W., & Löwe, B. (2006). A Brief Measure for Assessing Generalized Anxiety Disorder: The GAD-7. *Archives of Internal Medicine*, *166*(10), 1092. https://doi.org/10.1001/archinte.166.10.1092

Stamm, B. H. (2010). *The concise ProQOL manual*. Pocatello, ID: proqol. org.

Stanley, A. E., & Jha, A. P. (2010). Mind fitness: Improving operational effectiveness and building warrior resilience. *Fires*, 17–23. http://libproxy.nps.edu/login?url=https://search-proquest-com.libproxy.nps.edu/docview/199616172?accountid=12702

Ungar, M. (2006). Resilience across Cultures. *British Journal of Social Work*, *38*(2), 218–235. https://doi.org/10.1093/bjsw/bcl343

Vanuk, J. R., Alkozei, A., Raikes, A. C., Allen, J. J. B., & Killgore, W. D. S. (2019). Ability-Based Emotional Intelligence Is Associated With Greater Cardiac Vagal Control and Reactivity. *Frontiers in Human Neuroscience*, *13*, 181. https://doi.org/10.3389/fnhum.2019.00181

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063.

Weissman, M. M., & Bothwell, S. (1976). Assessment of social adjustment by patient self-report. *Archives of General Psychiatry*, *33*(9), 1111–1115.

Wu, G., Feder, A., Cohen, H., Kim, J. J., Calderon, S., Charney, D. S., & Mathé, A. A. (2013). Understanding resilience. *Frontiers in Behavioral Neuroscience*, *7*. https://doi.org/10.3389/fnbeh.2013.00010

Zimet, G. D., Dahlem, N. W., Zimet, S. G., & Farley, G. K. (1988). The multidimensional scale of perceived social support. *Journal of Personality Assessment*, *52*(1), 30–41.

THIS PAGE INTENTIONALLY LEFT BLANK

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Ft. Belvoir, Virginia

2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California